PROCEEDINGS OF THE COLLOQUIUM ON BREEDING AND SELECTION FOR CLONAL OIL PALMS

ORGANISED BY:
THE INTERNATIONAL SOCIETY FOR OIL PALM BREEDERS

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Note:

The paper on "Breeding and selection for cocoa clones" by Mr. Jamadon, MARDI was presented orally at the colloquium but the manuscript, was not available in time for inclusion in the proceedings.

PREFACE

It was in 1981 at the International Oil Palm Conference, when the *Institut de Reserches pour les Huiles et Oleagineux* (I.R.H.O) reported their success in regenerating oil palm plantlets using leaf explants, while Bakasawit/Unilever, reported the preliminary results of their first clonal trials. During these five years, many tissue-culture laboratories have been set-up and many palms have been put into culture. Although a number of new laboratories have succeeded in obtaining plantlets, a number of bottlenecks in the commercialisation of the tissue culture technique have been discovered. It would seem to be an appropriate moment to get the tissue-culturists and plant breeders to come together and compare notes so to speak *i.e.* to review the current status of the tissue-culture techniques and ortet selection, and to exchange ideas and information an areas where the tissue-culturist and the plant breeder can complement each other in achieving the goals of clonal propagation and of other aspects of crop improvement.

This Proceedings documents this one-day colloquium among the oil palm breeders and tissue-culturists, and adheres closely to the contents and sequence of the presentations. Only very minor editorial changes have been made. No editorial review of the scientific content has been attempted; the scientific accuracy and opinions expressed are the responsibility of the authors.

March, 1986

Editors
Soh Aik Chin
N. Rajanaidu
Mohd Nasir Hasan Basri

APPRECIATION

The International Society for Oil Palm Breeders (ISOPB), the organisers of this Colloquium, wishes to express its gratitude to the Director-General, PORIM for use of PORIM's excellent conference facilities, to Mr. B.J.Wood for so ably chairing the entire colloquium, and to the authors and others who have contributed in the form of papers, participation, encouragement and assistance, to the success of this colloquium.

The Organising Committee wished to thank Dr. Soh Aik Chin and others for editing the proceedings of this colloquium.

March, 1986

Organising Committee

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Secretary : Dr. N. Rajanaidu

Members : Mr. Tan Swee Tian
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WELCOME ADDRESS BY PRESIDENT OF ISOPB

Mr. Wood, Chairman of Colloquium
Ladies and Gentlemen
Welcome to PORIM

This is the second major function organised by the International Society for Oil Palm Breeders (ISOPB) which was established in 1983. In 1985, ISOPB and PORIM jointly sponsored the International Workshop on "Oil Palm Germplasm and Utilization" which was a great success.

Today's function is a one-day Colloquium on "Breeding and Selection for Clonal Oil Palms". Various issues pertaining to the development of oil palm clones will be discussed during this Colloquium.

Current and anticipated situations of depressed oil palm prices and market competition (by low cost producers) compels the need to increase productivity to lower unit cost. Clonal propagation and the expected quantum jump in yield with its application is one of the brightest star on the horizon in this respect.

The technique of oil palm *in vitro* propagation was first established about a decade ago and since then many more laboratories have ventured into this area and each had their share of success in regenerating palms from tissue culture; and it does seem to come through to the prediction by some people that the technique will be a common knowledge and practice. As you would probably hear in the session on the current status of oil palm tissue culture, this is not quite so as there is still some inherent problems which hopefully can be resolved subsequently.

In vitro propagation is only a tool; a propagation method like any conventional vegetative propagation method; and the real success of the process from the point of benefit to the industry, is the availability and continuing availability of superior clones.

Much has been speculated about the quantum increase in yield achievable with clones and preliminary results are becoming available. To some it does seem an easy process to just go pick a superior palm and clone it and one would achieve the yield increase. As you will hear shortly, this is not quite so.

It is indeed timely now to get the tissue-culturist and breeders and agronomists together in a forum to discuss and review the current status of clonal propagation and breeding and selection for clones, to come to some common strategy or to devise alternative strategies to exploit this new tool to its maximum.

Today's Colloquium will be chaired by Mr. Wood who is well-known and needs no introduction. I have my full confidence that he will chair the Colloquium ably and now I leave the Colloquium under the hands of Mr. Wood.

Wish you all the best including our foreign guests. Thank you.

CHAIRMAN'S OPENING REMARKS

B.J. Wood,
Ebor Research, Sime Darby

Tan Sri Datuk Dr. Anuwar, distinguished guests, members of the International Society for Oil Palm Breeders, and other delegates to this Colloquium. First of all I must thank Tan Sri Datuk Dr. Anuwar for the kind words he said about me. I hope that by the end of the day, he still might feel me worthy of such confidence!

This is the first colloquium of its kind that has been held by ISOPB, but I believe that it is the first of a series that they intend to hold on topics of a technical nature. Most of you are aware that this particular one is actually organised by ISOPB. Their objectives and terms of reference are in the paper that has been given to you this morning, so you can find out all about the organisation there.

I believe that it is not necessary for me to occupy more than a few minutes on tissue culture, because much of what I might have said has already been covered in Tan Sri Datuk Dr. Anuwar's very succinct introduction, and by the slide show you have just seen. One thing I would like to say is that the point from which cloning might now take off is one that has been established by plant breeders – despite the particular difficulties of a kind that do not exist with field crops like corn or wheat. One of the main problems with tree crops is that they cannot be bred very rapidly. Oil palm takes at least eight years in the field before one can make a reasonable evaluation, and even then, it really needs looking at for a somewhat longer time. Further, one palm occupies a lot of space, equivalent perhaps to several hundred wheat plants. Even so, in the search for efficiency, a good deal of progress has taken place. If we say scientific plant breeding started 50 years ago, this still doesn't imply that no selection happened before that. I am not one of those who subscribes to the idea that prior to the beginning of what might be called the scientific approach, people were incompetent or incapable of improving domesticated organisms by making empirical associations. In fact empiricism is what science is about at some point, assessed and used in a systematic manner. I cannot believe for example that the excellence of the Deli dura was due to pure coincidence. I believe that it had been sought out, and was known to be good.

During these 50 "scientific years" there have been many major advances, apart from what was a true break-through in scientific terms, the elucidation of the dura/pisifera gene in the production of teneras. It is difficult to say what proportion of the advance has been due to breeding and what has been agronomic. In total, the improvements have led from yield expectations in the mid-1930s of perhaps 4 or 5 tonnes per acre (sorry to refer to acres, but that is what palms were grown on then), which has now risen to perhaps three times that in some of our better environments. Obviously, the dream of selecting individuals and propagating them as clones, as can be done with several other tree crops, has always existed, but it had to be only a dream until the discovery of the tissue culture technique. You have heard a brief summary of its application to oil palms from the mid-seventies already, and you will be hearing more details through the day, so it is unnecessary for me to say more about it now.

I would like to re-emphasise one point we have already heard, concerning average oil yields. In cases where detailed assessments have been done, oil yields in the range of 5 or 6 tonnes per hectare on average have been found, but yields of individual palms can equate to two or three times

that. This means that we can be looking to major advances, if individual palms produce ramets true to type, and if it is not simply a question of superior competitivity on the part of those individual palms (and which therefore would not occur if they were growing alongside equally capable neighbours). These are the kind of questions that need to be answered. Several of the clones that are being produced at the moment by various organisations are derived from pedigree seeds and these have to be field tested. That is not necessarily a bad beginning, because most of us believe that even if you select an individual palm in the field, at that stage it is impossible to know what proportion of its phenotypic superiority is genotypic. In other words, how the ramets will perform. Therefore, we have to field test anyway. This initial beginning mostly of clones produced from high pedigree seeds, has been because it is easier to clone from the material. Obviously, the future is going to lie in selection of individual palms, and we are going to build up much better knowledge about how the ramets are going to behave, in relation to the parent ortet. These are the kind of problems we will be addressing today.

Further we can look to a much faster incorporation of secondary characteristics in addition to oil yields, such as height gain, precocity, oil composition and many other things. These perhaps will be as important as yield in the future, simply because the development of the clonal technique makes it easier to select several characters at once.

I believe that the breeders still are going to have a major part to play. Nevertheless, first there will still be a need to produce seed materials, because don't forget, we are going to be looking at production of several million plantlets per year to maintain Malaysia's current area of oil palm; Even if the area stays stable, if you divide 1.5 million hectares by 25, you are talking about planting 60,000 hectares per year. This requires a lot of planting material.

So, the breeders are going to have a major part to play still, in producing seeds, for quite a long time to come. Also, they have to bend their minds to the new challenge, which is to breed specifically for cloning. In this they must aim not at population excellence, but at ways of getting wide variability so that choice can be made among individual palms, some of which have several outstanding characteristics, and not merely one.

Finally, a brief word on how we are going to conduct things today. We have a number of sessions. I won't go into what is going to be in each session, because it is in your programme, which is clear. Time-keeping is going to be important, because we have got a lot to get through. We do hope to get good feedback from the audience so we have to allow discussion time. At the end of the day, we hope to produce a Proceedings which will give a good account of the state of the art. This will benefit PORIM as Tan Sri Datuk Dr. Anuwar mentioned, because they require to know what will be the general view of this expert gathering about tissue culture. This will include how it is to be done, what is its potential, and what are the problems. All of this can be passed to PORIM, and will be available to all the other organisations, which you have got listed, and who are involved with tissue culture.

CLOSING ADDRESS BY

Dr. Haji Abdul Halim bin Hassan
Deputy President of ISOPB

Y.B. Tan Sri Datuk Dr. Anuwar bin Mahmud, President of the International Society for Oil Palm Breeders (ISOPB), Mr. B.J. Wood, the Chairman of this Colloquium, members of Programme Advisory Committee of PORIM.

Ladies and Gentlemen,

The International Society for Oil Palm Breeders (ISOPB) is a new organisation which had its inaugural meeting in 1981 in Kuala Lumpur and was eventually registered in Malaysia in 1983. This was made possible by the interest shown by the oil breeders and the hard work put up by our Hon. Secretary.

The general aim of the Society is to advance the knowledge of oil palm breeding through international cooperation. In order to achieve this aim, the Society has been organising various activities such as workshops, seminars, colloqia and visits to leading research institutes. Last year, as pointed out by the President, we organised an International Workshop on "Oil Palm Germplasm and Utilization". Participants from more than 10 countries attended the Workshop. In addition, seminars on "Fatty Acid Composition" in oil palm and on "Hybrids" were also arranged by the Society.

This year, the activity of the Society is launched with this Colloquium. By the middle of this year, we will be organising a Seminar on "Recent advances in plant and animal improvement – theory and application". Four leading scientists in Malaysia will deliver four papers on this topic.

We also plan to organise a Seminar on "Quantitative Genetics" in later part of 1986. There are also plans underway to visit a leading tissue culture laboratory in Singapore in April/May this year.

The best advertisement for a Society is its activities and with the programmes mentioned we hope that those who are not members yet, will become members immediately. I understand that the application forms are available at the entrance. At present, our membership strength is more than 80 and intend to increase to 200 by this year. The executive committee has also discussed the possibilities of introducing student membership and hopefully this would be realised soon, after we amend our constitution to accommodate the idea.

The next annual general meeting of the Society will be held in 1987 in conjunction with the International Oil Palm Conference. We urge members to attend this meeting and also a workshop on the potential of hybrids which will be organised by the Society.

We hope to see most of you at the next function of the Society *i.e.* Seminar on "Recent Advances in Plant and Animal Improvement".

Thank you.

CHAIRMAN'S OVERVIEW

First of all I must thank ISOPB for honouring me by inviting me to be here as Chairman. When I also agreed to do a summary, I must admit I did not know what I was letting myself in for! People who know me well realise that when I get into lectures with slides, especially with a comfortable chair, I usually go to sleep fairly quickly. They probably decided that this involvement would be a good way to keep me awake all day.

It was George Bernard Shaw who said once he had not got time to write a short letter so he had had to write a long one. With being busy also moderating the discussions, I haven't had time to summarise my views and get them down to succinct points – so I can only hope that I don't ramble on too much, in summarising the day's deliberations.

It is clear that we have already made a lot of progress on tissue culture of oil palms. As we noted just now, if we take the example of rubber it takes 20 years from initial selection of a clone, to getting it planted on a wide scale. Therefore, I can't think that we shall be producing oil palm clonal materials for all commercial planting before at least 20 years.

It seems to me that much of the head scratching agony we are putting ourselves through is really because we are trying to get to an end rather too directly. I think we have got to accept that the development of clonal oil palms is going to go in progressive steps.

In Session A, we talked about the various factors that were correlated to getting maximum oil yields.

Dr. Rajanaidu outlined the route to optimum selection. He mentioned the difficulties of separating what is genetically controlled, from what are environmental interactions.

Mr. Rao showed that the yield pattern over a period of time might vary in different plantings with the same genotypes. However, there is not much specific evidence of that variable pattern, and certainly not enough at the moment to determine exactly how clones may behave. He pointed out that height, a favourite characteristic to be dealt with by cloning, is negatively correlated with yield, but this is statistical, so that there is a possibility of picking out high yielding clonal lines that at the same time show relatively low height gain. This of course is one illustration of the basic difference between breeding for seeds and for clones that will now have to be taken into account. In the latter, breeders will be attempting to make wide crosses to find individuals that buck the general trend.

We must remember that whilst it is the general assumption that height gain is to be given considerable importance, this is not proven. We assume that palms must be felled at a certain height rather than age. This refers to the proportion of a plantings that is immature. It might be quicker and simpler to achieve this by selecting for lines that are precocious, and achieve the same end. We have to keep an open mind and think laterally, in the face of all the new opportunities before us.

Dr. Arasu asked what seemed to be a very pertinent question at this point, when referring to the differences between pre and post-weevil yield and height gain correlations. We must remember that it is well established that most correlations were established before the onset of weevil pollination. But palms not well-pollinated gain height more rapidly because so much of their dry matter productivity, that would otherwise have gone into producing reproductive (bunch) tissue, goes into vegetative tissue. There has not been a sufficient time post-weevil pollination, to really determine the new rates of height gain, nor to find out if there has been any interaction whereby particular genetic lines show a different relationship than before.

Mr. Rao also referred to the question of oil composition. There is a temptation to think that if we can move the composition of palm oil in the direction of having a greater unsaturated component, this will *per se* automatically improve its value. Actually the evidence is that the market specifically likes palm oil as it is, and it is more likely that the new opportunity will lead us in the direction of being able to produce two types of palm oil, rather than that palm oil overall will change its characters. Various types of kernel oil and various relationships between quantity of kernels and palm oil, also exist. However even although we might now have the option of trading off kernels for palm oil, the decision as to which to go for would be very difficult indeed, and on the whole, one would probably aim at a mix that would give us much the same average as at present.

In Session B, we talked about the possibility of using various types of tissue for initation of the tissue culture process, where the roots or leaves of mature age palms are taken. We are forced to accept that only a relatively small proportion of the number of palms we field-select as ortets can actually be cloned, at the moment. No doubt there is a genotype factor, and only certain genotypes will be easily cloned. Luck seems to have it that there is no particular correlation between "clonability" and yield.

Ms Wooi described some of the problems of commercial production, including the requirement for upscaling in a manner compatible with still giving detailed attention to cultures. She drew our attention to the possibilities of introduction of techniques from higher technology, including genetic engineering. The possibility of direct production of embryos encapsulated in a coating resembling a seed seems attractive. All of this is acknowledged to be very much in the future, notwithstanding Dr. Raju's apparent success in developing a practical technique in a very short time.

Mr. Kanagaratnam described the progress that could be made in a relatively new laboratory venture, by attention to basic principles, and a very direct approach to the primary objective.

Discussion of this session featured the relative merits of producing clones from seeds or seedlings against mature palms. It was generally felt that production of clones from pedigree seeds was easier than from selected field ortets, and that in any case extensive field tests of clonal lines were needed. The point was made that if we assume average yields from a reasonable number of clones, then extensive field tests can be carried out without any loss of yield in the test areas. Thus it seems good strategy to add a multiplicity of clones from seed sources to field selected ortets for field evaluations.

In Session C, Dr. Soh poured some cold water over the idea that substantial yield increases would be immediately possible from tissue culture, simply by the identification of outstanding ortets, and the planting of their ramets. He referred to the low heritabilities that feature in yield patterns, and calculated that the 30% yield improvements forecast for the first generation of clones may turn out to be what the geneticists might call a "double-cross"! As I interpret what he was saying, it is not necessarily going to be easy to get these levels of yield increase in the first generation, because of the difficulties of estimating heritability, but that in the longer term, after selec-

tion of clones from extensive field tests, considerably greater yield increases might be possible. I stand to be corrected by him on that.

It seems to me that heritabilities are, at the present moment, a useful tool in estimating the degree of progress we might make, but we must bear in mind that they do not allow total precision in any individual case, in separating the genetic from the environmental component in field performance. Once we get to the stage of having clones widely field tested, then we shall be able to start to identify much more precisely those that are truly outstanding. As things currently are, we can only assume that there is a greater probability that a clone will be good if it derives from an outstanding ortet. The extent of this probability we cannot even exactly quantify.

Dr. Soh emphasised this point and whilst it is possible that cloning may perpetually remain a very difficult thing to do, there is always the possibility that we can develop "clonal seed-gardens". These would allow the cloning in relatively small numbers of the parents of outstanding crosses (what the geneticists refer to as specific combining ability) which could then be planted, so that instead of only a relatively few seeds from outstanding individual crosses, we could have more or less infinite numbers of each cross.

In the long run, this might be a little less satisfactory than cloning from seeds, and then multiplying up the best ones. In this case, the idea is to come back to the best clones, and continue to produce those. This is the strategy that a lot of us are adopting, at least initially, even though it may be perforce. The two approaches offer alternatives to production of clonal lines from outstanding ortets. As the speaker pointed out, there are several strategies open to us. It will require time not only to develop each one, but also to compare them and see which is the best in practice.

Dr. Rajanaidu showed us that the yields of the best progenies (as distinct from individual palms) still are quite a bit ahead of the average yield of a particular planting. Of course, the best individuals in those families are better still. So there is scope for major advances in productivity.

Mr. Chin summarised Felda's strategies. Their objective is to look for the best oil-producing progenies, and within those, then look for ones which combine this with the slowest height increment. This is a very common sense approach to take. They look particularly for palms, by simple phenotypic inspection, which appear to have good partition of assimilates. In other words, high yields but small in the vegetative sense.

Obviously, the great variation that occurs in the field means that we must look forward to a period of extensive clonal testing. I personally think that whatever else happens, this is the route that most of us will be following. For some time, we shall have to limit ourselves to blocks of clones in the field planted for assessment and comparison. The point came up that a lot of the new materials coming in may be incorporated into commercial production earlier, because they can be expanded by the clonal route, rather than have to be incorporated into breeding programmes.

In Session D, we considered the information that we can derive about oil palms from other crops. The message from rubber presented by Dr. Mohd. Noor seemed to centre on the long period of time needed for positive assessment of performance. Notwithstanding this, even though the first clonal plantings only really took off in the post war period, which is only about 40 years ago, still by now, virtually no seedling material is planted commercially. And yet the time lapse to identify a new clone as good is 20 years. It would seem from this that once we get moving on large scale oil palm clonal production, seedlings may rapidly become a thing of the past, for large scale commercial planting. It doesn't follow absolutely necessarily, of course, for many reasons raised in this Colloquium, but it does suggest there will be a long lead time followed by a spate of exponential growth in exploitation.

When Mr. Chan Ying Kwok told us something about fruit crops, it was evident that there was a much more difficult problem, because with fruit crops, standards of performance are not so objective. It is not simply a matter of weighing the amount of fruit the tree produces, nor measuring the tree size. Selection has got to be for intangible things such as taste. We look forward to getting from MARDI an odourless durian, which has all the taste qualities, but none of the smell! That is what Europeans tend to prefer, so I am told; but I personally like nothing better than to have a smelly durian in the back of my car. Further confirmation that it is all rather subjective!

Dr. Baudouin told us what IRHO were doing, in a very brief coverage added to the programme at the last minute. This was very interesting to us, because it is work we are not so familar with. I think that none of us would disagree that to have the best assessment of the potential of palms, it is preferable to have measurements at two distinct ages. That, of course, adds to the lead time involved. Many of us have been following what IRHO have been doing on mitochondrial activity, and we note that at the moment, it is not entirely clear how it is going to relate to ortet selection. The speaker put strong stress on the environment versus genotype problem. We learned that from 170 field selected ortets, IRHO has already managed to get 87 of them to produce at least some embryoids, and 28 have gone fully polyembryogenic, which is encouraging to them and interesting to us.

I might add here that the last term, polyembryogenic, which was coined in Dr. Paranjothy's paper, should, I believe, become adopted. We are all beginning to realise that going embryogenic, and being able to get a lot of plantlets, are two different things. It is thus useful to have a term to distinguish the two.

We were also glad to note, in the discussion period, that IRHO are prepared to extend their trials to a third continent, namely Asia. We would like to compare their materials with ours, and we hope that they will want to compare ours with theirs in the other areas. Further, we look forward to their results on cryopreservation, because obviously with all these long time scales, the clone that has gone polyembryogenic must then be tested in the field. Once enough are produced for field tests, no more are needed unless and until it is proved they have commercial value. So they have to be kept "on ice" in some way until you want to come back to them. With this, multiplication and the needs for costly laboratory transfers can be slowed down for some time in between, which would be very useful.

Dr. Rajanaidu, in reviewing desirable characters, again dwelt on environmental interaction, and he introduced a new point to the delegates. This is that there may well be interactions with agronomic practices such as fertiliser programmes, spacing, and pest and disease occurrence. Thus, the job of the agronomist in dealing with clonal plantings may become different. It occurred to me at this point that we have a number of such problems to sort out, and the earlier the better. Assessments on such matters should come into our clonal tests. Also, at an early stage, we must decide if it will be best to plant clones for the field in a lattice layout, in rows, in blocks, or plant entirely one clone in one field like we do in rubber, or what. I think we ought to think about these problems as early as possible. He told us about the initial screening method, and early published results. However, we are quite prepared to accept the statements of the people carrying out the oldest field trials at Bakasawit and HMPB, that they really feel it is too early to give even preliminary indications, because things are continually developing. Rankings in trials are still changing, and we look forward to results as they get to a stage where they are beginning to look more stable. Obviously, we do need to know, as an industry, things like whether there is a marked clone/environment interaction, and if there is, how big it is.

In the discussion, Mr. Ollagnier raised the point that from seedling material in very extensive plantings in Ecuador, production was up to 30 bunches per palm. He wanted to know if we could better this. The obvious answer is no, we can't really, and if we do then the palms could produce virtually no pollen, so there is not much point. In other words, there is a limit to the number of bunches we should go for.

Right near the end of the day mantled fruits raised their ugly heads, by courtesy of Mr Tan Yap Pau. I think the conclusion about that discussion was that he might be very unlucky to have got four clones out of four like that, whereas other organisations admitted to only two in total. Nevertheless, the possibility must continue to be accepted that other things could have happened, either in the production of these clonal plants in the laboratory, or something in the field. We must hope that this is going to be followed up. Presumably the organisation that supplied those clones is going to be looking into it with him, to find out whether there is anything identifiable and controllable that could be involved. It is clearly an important matter that should be kept in the open and not hidden. There is no advantage to anybody in hiding it.

En. Jamadon Bahari touched on cocoa, and it appeared that whilst ortets could be selected as being well above average performance for their family, their ramets came back towards the average. As was said, there is clearly the possibility that rootstock interaction was involved in moderating their performance.

In the General Discussion period, among the main points that I noted are that there is need of a task force to decide where developments on oil composition should go. I had the impression that everyone endorsed the need for that. The story we get from refineries is somewhat equivocal. I am not an oil technologist, but in my interpretation, evidently it is not simply a question of the iodine value. There are other factors that are involved, and as far as the iodine value of oil from interspecific hybrid palms is concerned, the improvement from the point of view of the manufacturer is not quite as good as it might look to the agriculturalist. So we would certainly go along with the need to get an authoritative industry view on that. This would have to include views from representatives of manufacturers, refiners, and food technologists. The agriculturalist needs guidelines, because we don't want to retain quite large areas (40 of 50 ha.) of land for speculative hybrids, which are a current practical source of contention with the mills, if there is no prospect in the final analysis that even a few individuals may possess particularly useful characters.

Evidently PORIM intend to complete, in due course, a full cross section of all oil palm germplasm. This obviously is desirable, particularly bearing in mind the way in which wild forests are disappearing. It may well be that natural materials won't be available one day soon.

A personal view I formed, or, to be more precise, which I have had for a long time, and which was not dented by today's discussion, is that no one in the industry will gain benefit by too much close secrecy in their work on the tissue culture of oil palms. The number of clonal plants that will be required is huge, once the right clones for commercial plantings are available. The capability for production by individual labs, at the moment, is limited. So even the minor advantage of selling a bit of planting material is not likely to be denied to a range of producers because of competition. What is really important to the industry is to maximise production on its land area. That comes from planting the best material – and if that means clones, planting the best clones. Not the organisation's own clones, necessarily. If several organisations produce a few clones each, that does not mean that each should only plant its own clones. Each has got to go for the best, to maximise its profit from its acreage. The more open we are about our testing programmes, and the more we interchange clones and compare each other's clones, the more likely it is that the industry as a whole will get the best clones the quickest.

A final word, what do we have to do next? There is a long way to go. It could be 20 years before we are putting clonal plantlets into the ground on a large scale commercial basis, as was said earlier. In the meantime, seedlings remain all important. This means that for the coming years, the breeders are going to have two rather different jobs to do at the same time. One is breeding to maintain the high quality of materials that we currently use, and to improve them. The other is to develop new breeding schemes wherever it is appropriate, going for what might be called wide crossing, to produce materials of extreme variation, a few of which might be suitable for cloning, combining all the different characters that have now become potentially combinable. The agronomists will have to be involved in this. There will not be the buffering in a planting that is conferred by the current mix of genotypes. Take for example, spacing. Where seedlings are planted at one spacing, some genotypes will do better than others. Had the same genotypes been planted at a different spacing, the rankings would have changed, but still some of them would do better, so there would still be near to an optimum yield, providing there is not too big a departure from the best possible spacing. Single clone blocks are likely to be very much more sensitive to deviations from optimum. Also, environmental influences will be greater at a constant spacing. Fertiliser input needs may be much more precise. Another buffering that may be noticeable missing in clonal plantings is susceptibility to pests and diseases. There may be some that attack a particular genotype, but are affected by differences in surrounding genotypes which thus slows things down, to give time to deal with the problem.

Finally, we have to decide whether there is going to be such a big clonal environment – interaction that we need to govern our clonal selections to specific localities, soil types, terrains and so on. It looks at present as though palms may be more sensitive than is rubber, an example with, which we are most familiar as a clonal tree plant. This could be partially due to the fact that palms wouldn't have any rootstock interaction, a factor that may lead to some degree of buffering in rubber. Possibly this and other factors yet unconsidered, will have an impact.

I have formed the impression during the day that it was a good idea to hold this Colloquium. I would compliment the International Society for Oil Palm Breeders on their initiative in setting it up, and PORIM for holding it. As Tan Sri Datuk Dr. Anuwar has said this morning, PORIM intends to hold such colloquia in future. I believe that this is an excellent proposal. With that, I thank you very much for your attention.

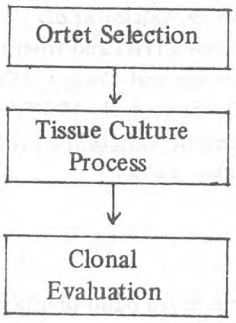
SESSION A: SELECTION CRITERIA FOR CLONAL PROPAGATION

SELECTION CRITERIA FOR ORTETS

N. Rajanaidu*

INTRODUCTION

The development of oil palm clones can be divided into three phases. They are:



Phase I

Phase II

Phase III

The "ortet selection" and "clonal evaluation" phases are carried out by breeders while the multiplication of explants derived from the selected ortets is handled by the tissue culturists.

In this paper, I shall discuss the first phase *i.e.* ortet selection, especially the criteria used for the selection of ortets for vegetative propagation.

Selection Criteria

The selection criteria discussed here are applicable both for the selection of ortets, crosses and parents for breeding. With the availability of vegetative propagation technique in oil palm, it is possible to select many traits simultaneously in a single palm and fix and multiply them in large numbers by tissue culture method.

Oil Yield

The most important character in ortet/elite cross selection is of course oil yield. This is conveniently broken down to FFB/palm/yr and oil extraction rate (or oil/bunch). In the past considerable attention was devoted to recording FFB production. The emphasis must now be firstly on oil extraction rate per palm, and secondly, its FFB production. Since the extraction rate is under much greater genetic control, it will be reproduced more exactly by tissue culture and is less subject to change under environmental vagaries including interpalm competition.

For example, Corley (1982) has given the following example to illustrate the importance of oil extraction rate:

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TABLE 2: MOST OUT-STANDING TENERA PALMS WITHIN THE NIGERIAN PROSPECTED MATERIALS.

PALM NO.	PROGENY	AV. YIELD (6TH - 8TH YR)	FL (M)	HT. INCREMENT (M/Y)	FRUIT COMPOSITION %F/B	%M/F	%O/B
2793	09.03	228.7	5.45	.19	67.01	77.05	29.48
7403	16.05	217.5	5.61	.23	60.85	83.54	28.07
3933	17.06	206.7	5.02	.28	62.00	87.67	31.23
1791	18.08	201.1	5.12	.16	66.19	81.00	30.50
1751	19.02	217.2	5.11	.24	61.19	85.15	28.35
3207	19.06	198.5	4.92	.18	60.64	83.53	29.10
4385	19.14	219.3	5.16	.24	69.96	78.3	30.33
1931	19.15	200.2	4.94	.26	65.42	83.1	28.53
3752	27.02	212.5	4.94	.26	65.42	83.1	28.53

Note:

Present commercial materials ht. increment = 0.45 - 0.72 m/y

TABLE 3: HIGH IODINE VALUE NIGERIAN GERMPLASM PALMS.

Palm No.	C14:0	C16:0	C18:0	C18:1	C18:2	I.V
22	0.6	32.8	6.5	43.7	15.3	63.9
28	0.5	32.5	7.9	44.3	13.5	61.3
48	0.7	35.4	5.5	43.0	14.2	61.4
128	0.6	35.3	5.3	42.1	15.8	63.4
146	0.5	32.4	5.6	45.0	15.5	65.4
151	1.1	36.1	5.4	41.6	14.8	61.2
305	0.9	40.1	5.1	47.9	11.7	61.4
618	0.6	33.7	6.7	44.2	13.5	61.2
814	0.5	32.6	6.6	47.4	11.8	61.1
903	0.4	30.8	7.3	46.5	12.9	63.9
971	0.3	30.2	7.0	49.1	12.9	64.4
1662	0.9	38.0	5.5	47.4	14.9	66.4
1861	1.4	37.0	6.4	36.2	17.6	61.4

with high mean values. A small percentage of palms also occur in mediocre families. These too are selected for cloning.

A note of caution should be raised against ortet selection within commercial *tenera* blocks. No conscious effort is made to reduce environmental variance within such blocks, hence selection efficiency is lower even if the *teneras* are from good genetic stocks. As the major expense in ortet selection will be the subsequent testing of experimental clones, a higher frequency of inferior clones will reduce overall cost effectiveness.

Selection populations for ortets

Initially most of the ortets will be selected from the large number of yield recorded *tenera* palms from DxP, DxT, TxD, TxT & TxP controlled crosses. These crosses are mainly tailored to produce uniform DxP seedlings material. In Malaysia, a more flexible scheme involving family selection and progeny testing is practised (Ooi, 1978). This method mainly exploits the general combining ability (GCA) of the *pisiferas* and *duras*. In Africa, the Nigerian Institute for Oil Palm Research (NIFOR) and *Institut de Recherches pour les Huiles et Olegineux* (IRHO) have adopted the reciprocal recurrent selection scheme (RRS) (Meunier *et.al.*, 1972).

With the advent of vegetative propagation, there are other ways to produce superior palms for cloning. This is to create recombination between palms known for high yield and complementary for different interesting characters:

(i) **Wide crosses**

This can be achieved by creating wide crosses (involving different origins). As pointed out by Meunier (1983) the parents for these wide crosses must be selected carefully to ensure that some of the palms of these wide crosses will accumulate the advantages spread over in different progenies. For example,

L2T x D115D (La Me x Deli Dabou) and L238T x L404 D (Yangambi x Deli Socfin)

are both very good crosses (high yield of oil per ha) but are different in their characteristics:

L2T x D115D	L238T x L404 D
High FFB	High oil/bunch
Slow growth	Rather tall progeny
Fusarium resistant	Fusarium susceptible

The past experiments have shown that L2T combines well with L404D and D115D. By producing the 'wide cross' (L2T x D115D) x (L238T x L404D), it is possible to create a progeny with a high average yield but with a large variability between palms. By combining the four populations (La Me, Yangambi, Dabou and Socfin) some extreme individuals with various combination *e.g.* high FFB, high oil/bunch, with slow trunk increment can be expected for cloning.

(ii) **D x T or T x D crosses**

At present, the palms selected for vegetative multiplication will be *teneras*. Fertile *pisiferas* may be considered but their yields are still low (Tang, 1971; Chin, 1981).

Rajanaidu & Rao (1985) had indicated the advantage of D x T(or T x D)crosses where both parents can be selected on individual performance which appears to contribute significantly to selection progress. The drawback with such crosses however is that ortet source is halved as 50% of the offspring are *duras.*

A method to improve the selection of an ortet within a cross through clonal evaluation.

It is easy to select a progeny based on its mean performance. However, it is difficult to identify the elite palms within a cross for cloning because of the low heritability for some of the economic traits *e.g.* FFB yield. This problem could be overcome if we clone at least 30 embryos per cross and produce at least 10 plantlets from each of the 30 embryos (clones). This will facilitate identification of elite palms through clonal evaluation.

CONCLUSION

Ortet selection has been based on a number of different criteria such as FFB, O/B, height and oil quality. The ortets are selected based on their progeny and trial means. In future other criteria such as harvest index (H I), yield stability, selecting ortets under severe prunning, palms under low nitrogen level could be used. With the present selection criteria, it may be possible to obtain 13 – 30% increase in yields with the clones. It is the subsequent progress which will be much more difficult and will require more careful selection and testing (Corley, 1983).

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IMPORTANT TRAITS IN ORTET SELECTION

Vengeta Rao

ABSTRACT

The production of oil palm plantlets by tissue culture methods has now entered a commercial phase. Individual laboratories are geared to produce thousands of plantlets each. For yet unknown reasons not all genotypes appear equally amenable to vegetative propagation. Hence a few will, inevitably, be multiplied manifold. It is therefore extremely important that palms considered for propagation by tissue culture be very carefully selected. Such palms must possess superior yield profiles with precocity being an added advantage. A very high standard of bunch quality, in terms of the oil extraction rate, must be attained in view of the large standard errors associated with this trait. Greater emphasis should be given to the mesocarp to fruit and oil to mesocarp ratios. Ortet palms must desirably have slow height growth. Selection for this trait should distinguish between height increment due to frond production and that due to internode elongation. Competition in monoclonal plantings is likely to be more marked than in current heterogeneous seedling plantings. Leaf area ratio, and perhaps harvest index, should also be incorporated in ortet selection programmes to yield clones more tolerant to such competition.

INTRODUCTION

The production of clonal oil palm planting materials by tissue culture is rapidly expanding. In 1986, the combined production of the principal laboratories is projected to be close to a million plantlets. These will, however, be derived from a limited number of palms as not every palm, or indeed progeny, appears to be equally amenable to vegetative multiplication (Paranjothy, *pers. comm.*). Hence a selected genotype, if successfully propagated by tissue culture, will be multiplied many times and planted to relatively large acreages. It is therefore extremely important that palms, or indeed progenies, intended for propagation by tissue culture, be very carefully selected. In practice, however, conventional selection criteria, tailored for the selection of parents of hybrid seed programmes, are generally employed.

These criteria are reviewed for ortet palm selection.

SELECTION FOR HIGH YIELD

High yield, a most desirable trait is also arguably the most expensive to precisely measure in an oil palm selection programme. Both the principal components of fresh bunch yields, the average bunch weight and to a lesser extent the bunch number, are considerably influenced by the environment (Meunier *et. al.*, 1970; Ahiekpor & Yap, 1982; Jacquemard *et. al.*, 1982). Records of annual yields of individual palms, even when averaged over five years, as traditionally suggested, have large standard errors and yield differences between palms, unless relatively very large, are usually statistically non-significant. Hence for ortet selection, the simple practice of selecting all palms above a certain high yield threshold would appear to be the safest course. Any ranking within the selected group, unless statistically confirmed, would otherwise be invalid.

* PORIM, Kluang.

The above be as it may, there is scant data relating the five year mean yield, commonly measured from the 4th – 8th year of field planting, to the average yield over the economic life span of the palm. Hardon (1969) obtained very low correlations between annual yields for the first eight years of yield measurement. *Table 1* shows the yield of 14 third generation Deli Dura, palms recorded at different age intervals. Of note in this data, albeit limited, is the clear absence of a correlation between early and total performance. Indeed it is quite possible for planting materials with superior early yields to have overall inferior profiles. This is clear from *Figure 1* which shows the actual profiles of two distinct types of planting materials grown in similar environments. Hence an ortet palm selected on high early yield, possibly a vigorous competitor, may give plantlets with poor overall profiles, especially when planted amongst like competitors.

It is obviously not practical to record the yield profile of a palm identified for vegetative multiplication. However some of the derived clonal plantlets could be planted to estate-size blocks, of 50 – 100 ha, in preferrably more than one location. Annual block yields are then obtained through the usual estate practice of harvesting individual blocks and recording crop volume at the mill. The profile of the clone in monoculture, after a period of 10 – 15 years, will be a valuable guide in the selection of the next generation of clones.

An important aspect of the yield profile, not quite obvious in *Figure 1*, is the superior value of early crop. In addition to higher valued returns on investment, unit harvesting costs are also much lower. *Figure 2* illustrates the marked change in (theoretical) profile differences when future crop is converted to its net present value. Early bearing, or precocity, is hence an important ortet selection trait. Blaak (1972) has shown that this trait is strongly heritable additively with marked differences between progenies. The precocity of some modern planting materials is in fact considered, by some researchers, to be an unconscious effect of continuous selection for high early yield. When selecting precocious ortet palms the emphasis should be on high oil yield as palms with similar bunch production can differ considerably in the extraction rate of initial bunches (*Table 2*). Similarly high bunch weight, to maintain moderate sex ratios, would be preferrable to high bunch number. The latter amongst others, could lead to problems of pollen shortage in young clonal plantings. Furthermore, palms that appear vegetatively very vigorous should be discarded to avoid producing clones with poor overall yield profiles.

SUPERIOR BUNCH QUALITY

The quality of the fruit bunches of a palm, in terms of the oil and, to a lesser extent, the kernel extraction rate, is a vital trait in any selection programme. Corley (1982) has pointed out the advantages of increased oil yields accruing from improvements in quality, in contrast to gains merely in fruit bunch yields. Furthermore, some bunch quality components are generally more heritable than bunch yield (Van der Vossen, 1974; West *et. al.* 1977).

In practice bunch quality is estimated by taking 2 – 6 bunches from each palm and determining the oil and kernel content by a method of "bunch analysis" developed by Blaak *et. al.* (1963). Seasonal influences, if any, and changes in bunch quality as palms age are incorporated by sampling bunches in different quarters within a year over a period of 5 - 7 years. However, since the method is expensive and there is no satisfactory alternative, it is unusual for more than 5 bunches to be analysed for each palm. It has been suggested recently that for current, rather homogeneous, D x P hybrid populations, the estimate of the average oil extraction rate from five analyses is too imprecise for rigorous ortet selection (Soh, A.C., *pers. comm.*). Indeed the conclusions appear to be similarly applicable to the relatively less uniform teneras in D x T progenies (*Table 3*). The table, based on the analyses of 8 – 14 bunches from each of 20 tenera palms of different D x T origin, shows that more than 50 analyses are required per palm to detect significantly a 2% difference in the oil extraction rate of palms. In the method of bunch analysis of Blaak *et. al.* (loc. cit.)

TABLE 1. COMPARISON OF EARLY YIELD, LATER YIELD AND AVERAGE TOTAL YIELD FOR INDIVIDUAL PALMS.

	yield (kg/an)			
Palm No.	5 - 10th yr (1)	15 - 18th yr (2)	23 - 26th yr (3)	av. total (4)
1	198.2	75.3	146.5	125.6
2	214.1	130.6	184.6	167.8
3	219.0	128.8	138.8	147.4
4	212.2	180.5	98.0	146.9
5	173.2	na	132.9	122.4
6	167.4	na	107.0	127.4
7	181.4	241.3	268.0	223.6
8	185.9	166.0	155.1	181.0
9	181.9	115.2	110.7	134.2
10	172.3	89.3	10.0	85.7
11	137.4	171.9	199.1	161.9
12	196.4	116.6	115.2	121.5
13	162.6	210.4	49.4	134.2
14	223.6	158.7	137.0	137.0
Correlations :	1 and 2	1 and 3	1 and 4	2 and 4
	r=0.24 n.s	r=0.06 n.s.	r=0.05 n.s	r=0.71 **

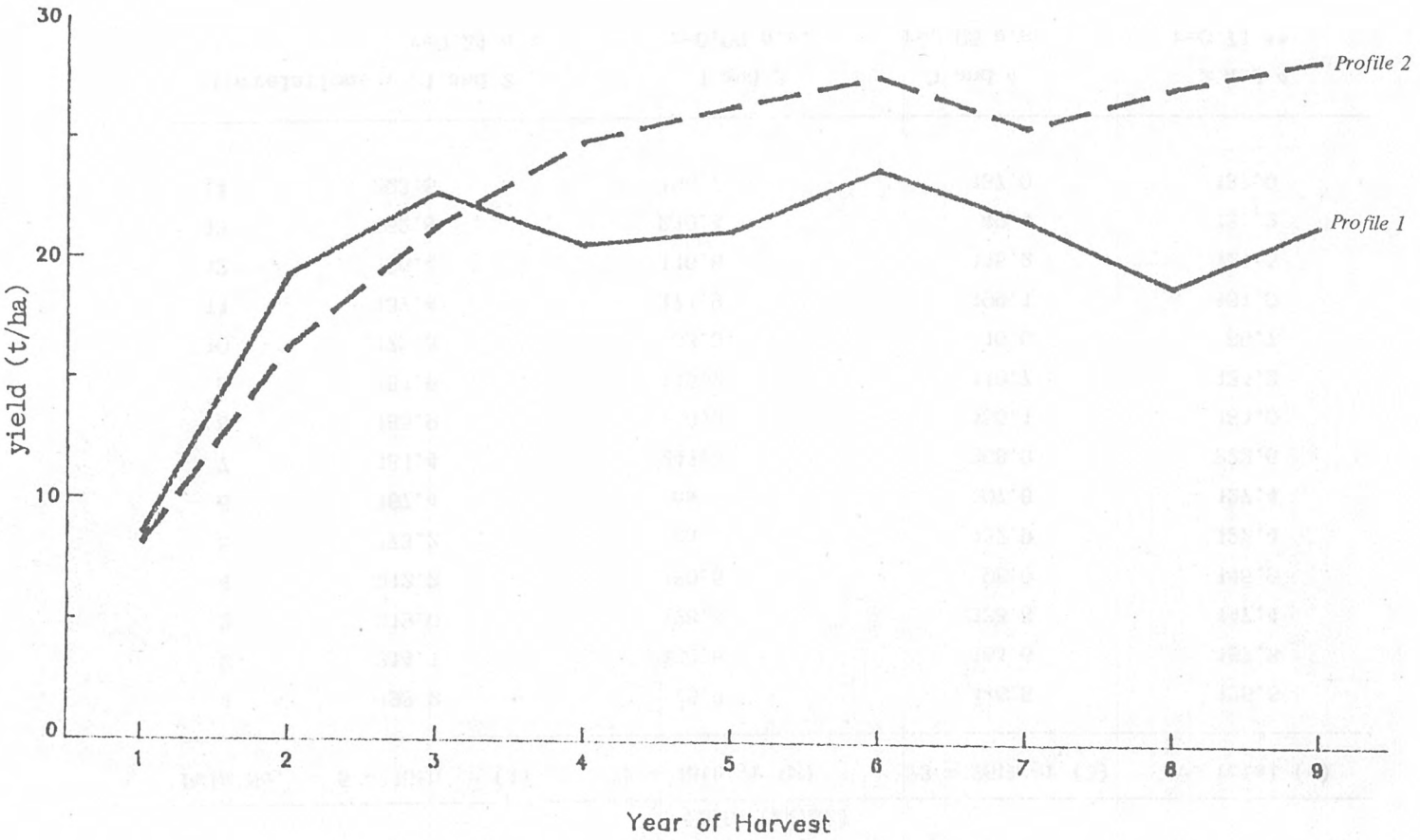

Figure 1. Comparison of two yield profiles.

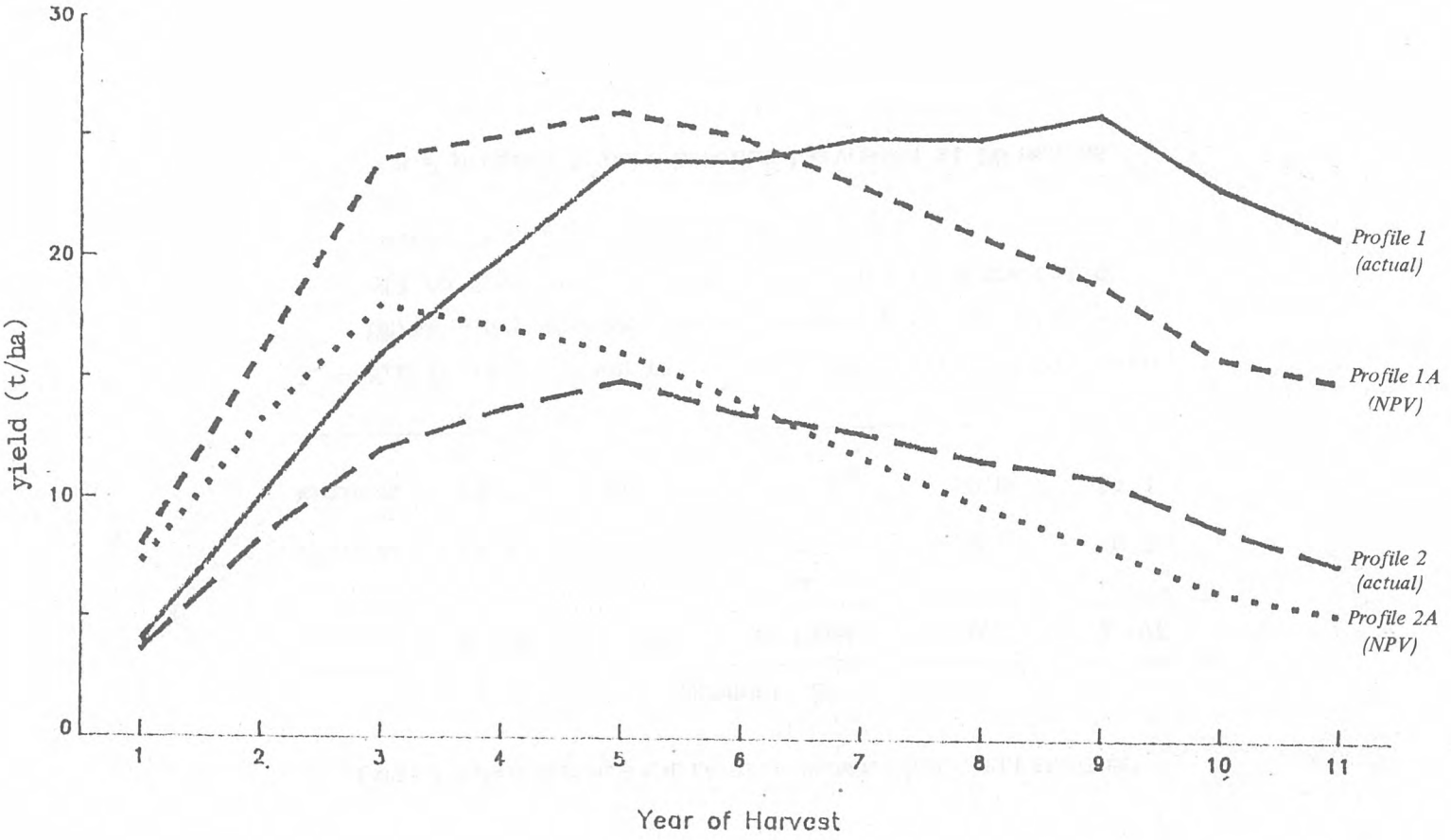

Figure 2. Comparison of yield profiles at net present values (NPV).

TABLE 2. RANGE IN BUNCH AND FRUIT COMPONENTS[1] OF EARLY BUNCHES[2]

	component (%)				
	% F/B	% M/F	% DM/WM	% O/DP	% O/B
Minimum	18.7	66.7	24.7	59.0	6.5
Maximum	72.0	87.5	63.3	82.0	31.1

1. - F/B fruit to bunch ratio, M/F - mesocarp to fruit ratio DM/WM - dry mesocarp to wet mesocarp ratio, O/DP - oil to dry pericarp ratio, O/B - oil to bunch ratio (also the oil extraction rate).

2. - D x P progeny trial, bunches harvested at 36 months

TABLE 3. PRECISION IN BUNCH ANALYSIS (no. of analyses required to establish significant differences between palms)

	component (%)				
	O/B	F/B	M/F	DM/WM	O/DP
coefficient of variation (%)	13.0	10.6	3.6	4.8	5.7
magnitude of difference (%) [1]	2	5	6	5	5
no. of analysis required for significant detection [2]	55	23	5	8	14

1 - The values for F/B, M/F, DM/WM and O/DP are equivalent to a 2% difference in O/B, other parameters being constant.

2 - At 5% significance with a probability of 90%.

the extraction rate is the product of four components. *Table 3* also gives the number of analyses required to establish a difference, equivalent to a 2% difference in the extraction rate, in any of these four components.

It is now quite obvious that ranking potential ortet palms by their bunch quality, as estimated from 2 – 5 analyses, cannot be very reliable. It would be more prudent to select all palms exceeding a high threshold value, 30% for example, for their oil extraction rate. Any ranking within the selected group, if necessary, must be confirmed by increasing numbers of analyses. Alternatively, where the number of analyses is limited, ranking within the selected group could be based on % O/DP (oil in dry pericarp ratio) and % M/F (mesocarp to fruit ratio) without undue reduction in the proportion of kernel to fruit *i.e.* select for very thin shelled teneras with high pulp oil content.

REDUCTION IN STEM HEIGHT GROWTH

The cost of harvesting oil palm fruit bunches escalates stepwise as palms grow taller, imposing an economic ceiling on gradually declining yields. Though the advantages of shorter palms was historically recognised, giving such selections as the Dump E206 palm, the Gunung Melayu duras and the Pobe collections, low height increment is a more recent vital selection trait. Some modern D x P planting materials, from commercial seed producers, now claim of short parents or ancestors in their pedigree.

Selection for low height increment, based on family means followed by individual palm values is relatively straight forward. Palm height can be accurately measured from ground level to a common reference point such as the base of frond 41. The rate of height increment is obtained by dividing this height by the age of the palm. It is important to mention the age, when specifying the increment rate, as the latter varies with the corresponding growth phase of the palm.

Despite its importance the biology of oil palm height growth has been poorly studied. There is very little growth in height of the young palm until the 3rd or 4th year when the stem becomes evident. The large number of smaller fronds formed during this period contribute to the inverted cone shaped bole, which has a greater diameter than the mature stem.

The subsequent increase in height of the actual stem arises from production of fronds in phyllotaxic sequence, as each frond base or node matures to a relatively large size, and also by internode elongation. Considered this way, the increase in height in oil palms accruing from frond production is more than twice that due to internode elongation, as the frond bases, at their widest point, are on average more than double the width of the average internode (*Table 4* and *Figure 3*).

Hence, where palms are generally similar in the width of their nodes and in their internode elongation, those with a higher frond production will initially at least, be taller. This point is important when considering the alternatives of high bunch number or high average bunch weight, as the former may result from greater frond production and not necessarily improved sex ratios.

Palms from different genetic populations appear to differ considerably in the width of the node *Table 4*. The shortness of the Dumpy palm, as an extreme example, corresponds with the considerable reduction in node width as well as reduced internode growth. The lengths of internodes, in contrast, appear to be influenced, to a greater part, by the environment. This is best seen in the considerably elongated internodes of palms grown at higher densities than normal. Node and internode widths, incidentally, do not appear to be related to trunk diameter (*Table 4*). Based on the above considerations, it would appear advantageous if the shortness of ortet palms is due, more to smaller nodes rather than shorter internodes. The latter may no longer be short when the clone in

TABLE 4. NODE (frond base) AND INTER-NODE WIDTHS IN DIFFERENT GROUPS OF PALMS.

Group	Node width (mm)		Internode length(mm)		trunk diameter (cm)	
	Mean	Range	Mean	Range	Mean	Range
TxP (tenera)	91.9	78.8 - 101.5	39.6	32.7 - 43.8	46.6	37 - 58
Commercial DxP	105.0	85.5 - 130.7	36.5	31.3 - 41.0	46.3	35 - 58
Deli Duras	92.4	82.5 - 101.5	28.9	25.2 - 32.5	41.6	38 - 46
Dumpy Duras	68.7	62.0 - 77.0	n.a.[1]	n.a.[1]	43.2	40 - 46
	C.V = 7 - 12%		C.V = 7 - 9%		C.V = 5 - 15%	

[1] Not available

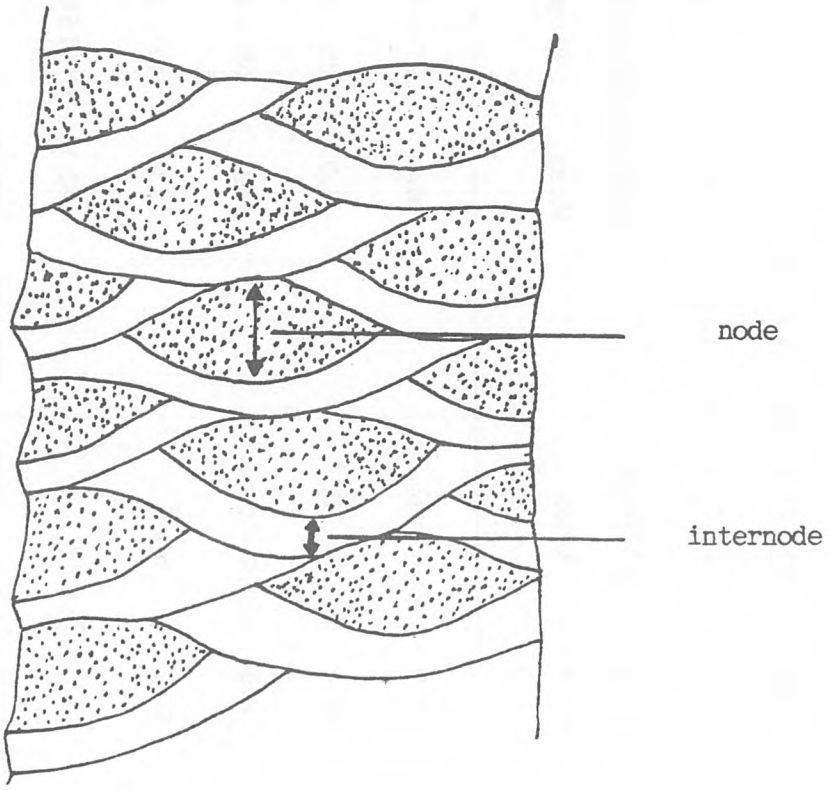

Figure 3. Portion of an oil palm stem showing comparative widths of node and internode.

planted in more favourable or competitive environments. These conclusions are, however, tentative as work on more precise measurements and heritabilities of these features is still in progress. It may be noted though that node and internode widths are relatively simple to measure.

VEGETATIVE TRAITS AND PHYSIOLOGICAL MEASURES

Though ortet palms may be selected on the basis of individual high yields it is obviously the yield per hectare of the resulting clone that is important. Inter-palm competition is an important consideration in such monocultures. To minimise possible competition, principally for light, Hardon *et. al.* (1984) suggested selecting for high bunch index (BI), the ratio of bunch dry weight to total dry weight. This, simpler version of the harvest index does not consider differences in oil extraction rates but is more conveniently applicable. Earlier work had shown moderate levels of genetic variance for this trait (Hardon *et. al.*, 1972).

Breure and Corley (1983) reexamined this trait in an environment much more favourable for vegetative growth and found individual selection to be ineffective. Breure *et. al.* (1984) proposed simultaneous selection for BI and LAR (leaf area ratio), since the latter was found more heritable and significantly correlated with BI.

The relationship between yield, BI, and some vegetative traits was reexamined in a very large population of germplasm palms (*Table 5*). The length and leaf area of fronds, unlike palm height increment, are strongly correlated wity yield. Hence competition is more likely to arise from canopy spread than palm height. However the latter, a component of VDM, is strongly correlated negatively with BI. Frond weight, another component, is also similarly negatively correlated. Hence selection for BI, where heritabilities are sufficiently high, will result in shorter palms with smaller fronds. However, unless yield levels are fairly high, such palms will also be low producers.

Squire (1984) examined the overall energy balance of the oil palm in different environments. He found that the primary bottleneck to greater productivity was the low efficiency of the oil palm in converting intercepted radiation into photosynthates. A conversion efficiency ratio, $E = W/fs$, where W is the weight of dry matter, s the solar energy received at the earth's surface and f the fraction of the same intercepted by the oil palm canopy, was proposed as a selection trait. This ratio was also calculated for the germplasm palms and is shown in *Table 5*. Because yield is a major component of TDM its correlation with E is almost 90%. As maybe predicted from the equation the other principal component of total dry matter *i.e.* frond weight is also strongly correlated with E. Hence, unless the heritability of E is considerably higher, it is not at all clear that selection for E will be more efficient than selection for yield and BI or LAR.

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TABLE 5. CORRELATIONS[1] BETWEEN YIELD, PHYSIOLOGICAL AND VEGETATIVE TRAITS.[2]

	HI	E	R.L.	Ht.	L.A.	L.Wt.	VDM	TDM
Yield	0.55	0.89	0.55	0.01ns	0.52	0.48	0.38	0.90
HI		0.49	-0.09ns	-0.42	-0.16ns	-0.32	-0.54	0.15ns
E			0.41	0.01ns	0.29	0.47	0.36	0.81
R.L.				0.03ns	0.85	0.82	0.66	0.70
Ht.					0.18	0.21	0.45	0.23
L.A.						0.84	0.71	0.71
L.Wt.							0.86	0.75
VDM								0.74

1 - n = 512 germplasm family means based on six palms each

2 - HI - Harvest Index, E - Efficiency of conversion, R.L - frond rachis length
Ht. - Height increment, L.A - Frond area, L.Wt. - Frond weight
VDM - Vegetative dry matter, TDM - Total dry matter

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JOINT DISCUSSION
SESSION A

Arasu

Regarding the precision of the bunch analysis figures, are they very recent figures or rather old figures? I asked this question from the point of view of the introduction of the weevil pollination, because most of your problems seem to stand from the low reliability of the fruit to bunch which of course has always been the problem, but what I hope with the more regular pollination this might have been reduced.

Rao

The bunch analysis covered a period from 1981 to 83 spanning the weevil period, the pre-weevil and post-weevil. This is the point I did not emphasise earlier, but nevertheless I think even after the weevils, we do still have a high amount of variation and I won't be surprised the fruit to bunch variation is still the largest. That is one point. The other point is with the fruit to bunch variation. It seems to be that the CV, is still much lower in certain kinds of materials than in other kinds of materials. That is the other point I did not mention earlier.

Chairman

Whereas fruit to bunch is said not to be very high on the list of characters that are heritable in Malaysia, it is always said to be more so in Africa and I have tended to put that down to the fact that they always have weevil pollination there. Whether in fact we should start to find that it, becomes a more heritable character now, remains to be seen. I think a lot of things have got to settle down now and we obviously got two to three years of recording so far *i.e.* post weevil. I think it is important that we bear this fact in mind and I think it is the important one that you have drawn attention to.

Tang

From the profiles that you showed us on the slide, I presume they are D x P materials?

Rao

Yes, Mr. Chairman.

Tang

If they are D x P materials, I also would assume that they are a homogeneous mixture of various types of D x P. Then there will be profiles indicating interaction between the material and the microclimate of the block rather than the material.

Rao

The profiles are from two different kinds of planting materials produced by the two different companies whose breeding programmes are running entirely different lengths, one using AVROS pisiferas and another using another set of pisiferas altogether.

Chairman

One of the things that one of the speakers asked for is how one might get the comparison over a long period of time. I think the only way is to wait a long time. May be other people have other suggestions on this.

Khoo

Coming back to the profiles again. Although the two materials were from two different origins, were they planted on the same estate and same environmental condition?

Rao

They were on two neighbouring estates and both of them were on the same soil type but if there is an implication that there could be block differences, I can't refute such implications because it will be very difficult as one needs experimental data to show that kind of thing. But the point is, I used the profiles to emphasise the point that selection based on early yields may not necessarily give the better accumulated profile.

Khoo

Yes, except that you know, although you said neighbouring estates, are there actually rainfall differences because you know rainfall has a big effect?

Rajanaidu

Mr. Chairman, I just want to make one comment. There is one instance where I correlated the first four years mean yield with mean yield over 20 years; the correlation is 0.9.

Chairman

There obviously are differences in yield patterns and obviously environmental differences come in to it and obviously also again we have to think of the pre-weevil and post weevil situation. May be we should be looking a lot more of any African data that we can get hold of to clarify some of these points and that may be one of the points of cutting across having to wait 20 years to get 20 years post-weevil data.

I would like to ask Dr. Rajanaidu on a different subject, oil quality. How many of the technical and end-use people involved in deciding that there would be advantage in changing the composition of the oil because I don't thank you universally agreed on it.

Rajanaidu

Mr. Chairman, we had a task force to study oil composition in palm oil and the conclusion was that it is worthwhile to produce at least a small percentage of the more unsaturated oil. Nevertheless there is a continuous demand for the present palm oil up to 70% or so. It is worthwhile to produce at least 20% of the more unsaturated oils especially if we can produce oil more than 72 I.V. where it can withstand cold temperatures of 4°C or so. As they look at the demand for oil, it is the unsaturated oil demand which is going to increase as years to come especially in salad dressing. So if

palm oil can penetrate that kind of market, it will give more flexibility and marketability of the palm oil.

Chairman

So basically we are talking about producing two different types of oils rather than simply gradually changing the overall composition because palm oil is a valuable commodity in its own right as it currently is. Another clarification, Mr. Rao, I would like to ask is what is wrong by just measuring the height to get the correlation to height and why do we have to concern ourselves quite so much on nodes and internodes.

Rao

I would feel if we just measure height then we would have to worry about frond production. If we go for short palms are we not going for smaller number of fronds? But if we said we go for high yield and short palms, that will take care of both. But the point is that if we bring the third character then we have to bring another to take care of both. Then the thing is why don't we study the height itself and see those population where internode growth is contributing to the stem height verses those population where it is the frond base which is contributing to stem height and I think that will be a first distinction before we go on to other aspect.

Soh

On that score, I just would like to bring up the point that there is always the fear that when you reduce the height, you reduce the yield because you reduce the frond production. If you look at the oleifera hybrids, the yields are very high and they are not very tall. Perhaps that would answer some of the questions.

Chairman

Perhaps what you are saying basically is that they are not necessarily negatively correlated.

Soh

Yes.

Chairman

Though they often are but not necessary and it is the exception that tissue culturists should look for.

Tan, Y.P.

Mr. Chairman, I would like to ask Mr. Rao whether when he measures the internode, is he measuring the distance between the base of the top internode and the top of the lower internode or is he measuring the top of the two nodes.

Rao

Mr. Chairman, one is being measured from the base of one node to the top of next node in a perpendicular direction.

Tan, Y.P.

If you measure top to top will that not be equivalent to your height itself. That means you measure the nodes with the internodes as a figure rather than measuring just the internodes itself.

Rao

The point is to distinguish the nodes and the internodes, to distinguish between the width of the nodes and the width of the internodes whereas if you measure from the top of the node to the top of the next node you will be measuring both together.

Tan, Y.P.

Yes that will be the height itself, so that means there is no reason to worry about the internodes or nodes itself.

Rao

We can measure height in various ways and there is no dispute, but we need not worry about nodes and internodes to worry about height but the point I wish to make is that we should distinguish between increase in height due to internode growth and that due to many nodes or due to frond production.

Tan, Y.P.

Mr. Chairman, I would like to ask Dr. Rajanaidu. In our attempts to go for oil to bunch, very high oil to bunch, what then becomes of the kernels. Have any attempts being made to study the economic contribution of the kernels and also is there any problems at the mills, with the very thin shells and the very small nuts.

Rajanaidu

Mr. Chairman, fruits with very small kernels do not mean that there is very little shells, in fact the mesocarps, kernels and shells are more or less interrelated factors, once you increase the mesocarp of fruit you more or less reduce the kernel and the shell. In our Nigerian population, we found that you can have about 5% kernel to fruit but you can have 10% shell to fruit and $>80\%$ mesocarp to fruit. That more or less will take care in terms of processing because the proportion of shell is important in terms of processing. At the same time you can also have a very small proportion of kernels especially if we feel that, at least now, kernel oil fetches such a low price, it is better to maximise your mesocarp oil rather than the kernel oil. We will be selecting some of the ortets in that direction but the economics changes so rapidly, that it is impossible to change our breeding programme overnight but it is always safer to have lines which will have high mesocarp oil and if you want to produce special lauric acid oil, you know that you also have palms which give $>30\%$ kernel to fruit.

Chairman

It will be nice to have those flexibility, but you still have to remember that palms you put in the ground today are going to be producing their fruits only in five years time in any quantity. I am letting things run on deliberately, not just because of anything get out of hand but because I believe that we can make up latter on and I think this is such an important subject.

Baudouin

We are concerned with the criteria of selection. It is important also to evaluate the variability of the environment especially for the bunch yield and if it is possible I want to present a technique that have been developed in IRHO to estimate one part of the environmental effect of the trials. This is a technique of smoothing that comprise four steps. The first step in a genetic trial is to suppress (to eliminate) the differences between crosses by dividing the yield of each tree by the average yield of each cross. The second step is to calculate the variance of the difference between two trees as a function of the distance. This function is called the variogram and it gives us a lot of information on the spatial structure of the variability in the trial, and the third step is smoothing of the data the average of each tree with its neighbour, and the optional coefficients are calculated from the variogram. The 'smoothed' data provide us an estimate of the effect of the geographical position of the tree and this effect is sometimes very important and the error made in this estimate can also be calculated. In the fourth step, it is the calculation by difference of the deviation of each individual tree from the average of the cross.

SESSION B: CURRENT STATUS OF CLONAL PROPAGATION BY TISSUE CULTURE TECHNIQUE

SOME ASPECTS OF OIL PALM TISSUE CULTURE IN RELATION TO ORTET SELECTION, AND CLONAL EVALUATION.

K. Paranjothy*

INTRODUCTION

The importance and anticipated potential of clonal propagation of oil palm is now evident from the large number of research and development laboratories which have recently been set up. This is perhaps also testimony to the successful application of the techniques of oil palm tissue culture to an extent where the method is considered a realistic practical proposition.

Several reviews have been published (Tisserat, 1981; Jones, 1983; Paranjothy, 1984; Wooi, 1984) and many facets of oil palm tissue culture are now adequately summarised. This paper will focus primarily on aspects that relate to embryogenesis and genetic stability, with particular reference to ortet selection and clonal evaluation respectively.

METHODS IN OIL PALM TISSUE CULTURE

Briefly, the stages currently used in clonal propagation of oil palm may be identified as follows: a) isolation of explant b) surface sterilisation c) initiation of callus d) callus subculture e) initiation of embryoids f) establishment of polyembryogenic cultures g) shoot development h) rooting and i) establishment in soil. Each *in vitro* stage has its own requirements in terms of nutrient media and culture conditions and often the optimum requirements may be unique to each individual clone. These optimum requirements for each clone are worked out empirically and this is often a laborious and painstaking exercise. In this respect the empirical aspects of the technology of plant tissue culture have not changed over the past twenty years and it is very likely that these empirical approaches will be a necessity until substantial advances in the understanding of molecular processes underlying development processes emerge.

FACTORS INFLUENCING CALLUS INITIATION AND EMBRYOGENESIS

It has been well known for a long time that factors such as explant type (e.g. roots, leaves, flowers, inflorescences, embryos, etc.) explant size, health and vigour of donor plants, genotype, age of donor plant, developmental age of explants etc., influence in a considerable way the successful initiation of cultures. In the case of callus cultures some of these factors also determine the frequency and speed of embryogenesis. In oil palm, at least in our experience, it is clear that similar factors are important. Thus callus initiation from seed embryos is easily achieved. Leaf explants from one to two year old palms, for example, yield callus far more readily than explants from older palms. Callus obtained from "juvenile" sources such as seed embryos, leaf explants of young palms, roots of aseptically grown seedlings seem to yield embryoids more readily than callus derived from explants of "mature" palms.

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CHOICE OF EXPLANTS

Some explants are intrinsically more difficult for tissue culture purposes than others. Roots, for example, require surface-sterilisation: over surface-sterilisation may lead to death of all explants while inadequate surface-sterilisation may yield a disappointing number of aseptic (but viable) explants. Roots are available year round, though roots harvested during drier spells often lack adequate vigour for callus initiation. Use of roots also incurs the risk that neighbouring palms may have been sampled inadvertantly. Leaf explants, in contrast, appear to offer some advantages. Surface-sterilisation is not essential and there is certainly no ambiguity about the palm being sampled. On the other hand, palms sampled for leaves face the risk of apical damage. This latter disadvantage, however, can be minimised with care during removal of the young leaves and adequate protective measures against rats and other pests. Callus derived from leaf explants is in our experience more vigorous in growth and tends to form embryoids more frequently than callus derived from root explants. Inflorescences can be removed without damage to the apex and do not require surface-sterilisation. Their callus yielding potential, however, seems to be lower than that of leaf explants.

IN VITRO BEHAVIOUR IN RELATION TO GENOTYPE

As one might expect from evidence gained with work on other plants, genotype does seem to have effects on some at least of the stages used in clonal propagation. Most of the work to date has been with tenera materials and within the context of this genotype it is clear for example that ortets from some crosses yield embryoids more readily than others. There is also evidence that shoots of some clones are more difficult to root than those of other clones. These differences are evident even between clones derived from a single cross. There are also differences in the rate of callus, embryoid and shoot proliferation. It is quite clear that some clones will be more amenable to rapid multiplication than others.

It is increasingly evident from work going on in various laboratories that duras and pisiferas are also amenable to cloning. It is quite possible therefore that clones of dura and pisifera parents selected for their specific combining abilities could be planted out in seed gardens for production of specific superior crosses. The main advantage of this approach of course is that superior seedling progenies will be made available more widely than at present.

It is also evident from unpublished work that *oleiferas* and their hybrids with *guineensis* are amenable to cloning. Breeding and selection for hybrid ortets could therefore be a useful pursuit.

Whilst all indications are that genotype does influence the amenability to cloning, it should be possible to design experiments to determine if important characters such as yield and oil quality, for example, have any role in this respect. Experiments of this nature probably have their own intrinsic value in breeding and selection studies, as for example in evaluating heritability estimates.

GENETIC STABILITY

Finally we ought to consider the genetic stability of the genome during *in vitro* manipulations. All evidence to date indicates that oil palm plantlets produced by *in vitro* methods are chromosomally normal. This is somewhat surprising in the context of evidence to the contrary available for various other species multiplied *in vitro* through a callus phase. There are plausible reasons, however, for the stability of the genome in oil palm despite the callus phase. Firstly, oil palm callus is in comparison with callus of many other crops rather slow growing. Indeed fast growing clones of callus in oil palm have reported to be chromosomally unstable. Secondly, once embryoids have been formed, there is little or no further involvement of callus in the subsequent stages. Admittedly

roots are induced in the shoots isolated from polyembryogenic cultures with the aid of callus promoting auxins. Anatomical studies however reveal root formation at the base of the shoots with minimal involvement of callus, as revealed in the continuity of the conducting elements between the shoot and root junction. Indeed chromosome counts of root tip cells have been reported to be normal and comparable to that of cells in the tips of roots of seedlings. Despite this evidence todate it is important that at least a small sample of plantlets produced be screened periodically for chromosomal stability. Plantlets are produced from polyembryogenic cultures that are continuously maintained by subculture and large scale propagation is not achieved (or perhaps even desired) at least until the clone is adequately evaluated in the field. During this period and also subsequently any genetic (or physiological) change would be multiplied and uniformly transmitted through subculture. There is furthermore the likelihood that some clones may be intrinsically unstable though evidence of this has yet to emerge. Field evaluations will give some indication of the genetic uniformity of plantlets but except for highly heritable characters will not easily indicate genetic differences from the ortet.

Besides cytological studies, genetic stability can be assessed by a variety of methods. Electrophoretic separation of proteins coupled with isoenzyme studies may provide some insight, besides hopefully providing a method for identification of clones. Other methods include study of plantlets sampled from embryogenic cultures at periodic intervals, comparison of plantlets produced from different explants of an individual ortet and of plantlets regenerated from callus reinitiated from several ramets of a clone. Regeneration of a particular clone through several successive generations of callus initiation and embryogenesis might be another useful approach.

PHASE CHANGE WITH RESPECT TO CLONING

In some plants, unlike oil palm, the distinction between a juvenile and adult phase is well defined. In rubber, for example, leaf fall and flowering can be used for experimental purposes to demarcate the juvenile vegetative phase of growth from the adult reproductive phase of growth. It has often been observed in these plants that some of the characteristic features of the juvenile or mature phase can be retained by vegetative propagation. Thus buds from juvenile rubber seedlings when grafted onto rootstocks will retain the stem conicity characteristic of seedlings. Buds taken from mature "source bushes" on the other hand reveal the cylindrical bole characteristic of the upper part of the seedling stem. In oil palm a clear distinction between a juvenile and adult phase does not exist. Changes in leaf morphology suggest physiological changes during early seedling growth indicative of phase change. In this respect it would be interesting to compare the morphological and developmental aspects, especially during their early growth, of plantlets developed from mature palm ortets and seedling ortets.

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THE CURRENT STATUS OF CLONAL PROPAGATION BY TISSUE CULTURE

A.J. Powell & K.C. Wooi *

The majority of the research and development work on the clonal propagation of the oil palm is currently being carried out by commercial organisations. There is, therefore, an element of secrecy which makes hard facts difficult to come by. However, there does exist, between the scientists involved, an informal dialogue, which allows us to form a general picture of the progress being made. This paper will therefore deal with our own personal experience and our impressions of the area as a whole. Generally speaking, therefore, it would appear that most laboratories share the same basic approach, which in fact, has changed little since the early work on oil palm tissue culture by Unilever Research and the IRHO in the mid 70's. The source tissue is either seed embryo or root, young leaf or inflorescence tissues from a selected mature palm. The choice of embryo or mature palm is open to debate and will no doubt be covered by other papers in this Colloquium There is some evidence that callus derived from embryo tissue is more likely to become embryogenic than callus derived from mature palm explants. It is certainly an easier tissue to work with, giving a sterile explant without the need to use severe sterilants such as mercuric chloride which we have found to be essential for root tissues. Large numbers can also be easily sampled. However, the character of the clone produced will only become known when it has been thoroughly field tested, a time consuming and costly operation. The use of tissue from a mature palm, on the other hand will give a clone, at least some of whose characteristics can be predicted. Our current knowledge of just which characters can or cannot be reproduced in the clone is restricted by the very small numbers of such clones now in the field. Also, the data we do have covers only the first two years of bearing. This must be compared with data from ortets which were mature when selected. We do, however, have two clones which are derived from seedlings which were subsequently field planted. The first ramets from these clones were planted less than two years after their ortets. We will therefore be able to follow closely and compare the development of ortet and clone from planting to maturity. As more clones from mature palms are field planted, our ability to select ortets for desirable characters will improve. The cloned seedling may be of some value in the short term but it seems certain that in the long term the mature palm will be the explant source of choice. On the question of which tissue to use, root explants are undoubtedly the easiest to obtain but suffer from high contamination levels. However, a palm can be sampled repeatedly. Using immature leaf and inflorescence tissues, it is easy to obtain large numbers of explants with the minimum of sterilisation. In the case of leaf, resampling is not possible then until the palm is fully recovered, which can take two years. The techniques of taking leaf and inflorescence tissues have now been developed to the stage where the life of the palm being sampled is no longer in danger, though setback is inevitable. This sometimes proves a problem when the selected palm is still being recorded. Opinion differs on which tissue gives best results and we know of no data showing any one tissue to be superior and most workers use all three. Regeneration always proceeds through the initial stage of callus formation, there being no reports of direct somatic embryogenesis or organogenesis on the explant. The use of activated charcoal in the culture medium seems to be currently in fashion, though appears not to be essential.

As has been the case from the beginning, control of embryogenesis has been the rate limiting step and progress has been slow. There is some evidence that there may be a genotype effect, some families being easier to propagate than others, though again data is scarce. Embryoid survival has sometimes been a problem but progress has been made here and we are now finding that most of

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the embryoids produced will survive and can be induced to multiply. There is some question as to whether the multiplication is of true embryoids or involves the formation of a morphogenic callus followed by callogenesis. Our own experience suggests the latter. Whenever a callus stage is involved, the question of somaclonal variation, which has been shown in other systems to be higher in callus than in other tissues, arises. The occurrence of "offtypes", though rare, is a fact, but what evidence we do have, though severely limited, suggests that variation, particularly in those characters of economic importance, is not significant. However, only when many more clones have been field tested will the true rate of variation be known.

In our experience, once embryoid multiplication has been achieved, regeneration of plantlets from all clones is possible, though the ease with which this can be achieved shows considerable clonal variation. Not all shoots will root and some plantlets die in culture without obvious cause. However, with the proper treatment, which involves the maintenance of the plantlet in conditions of high humidity for several weeks after transplanting, survival rates on transfer to soil close to 100%, can be achieved.

The techniques now being used for large scale production are still basically those of the laboratory. However the scale-up of this laboratory technique has not been without its problems. Our control over the biological processes involved is still less than complete. When only a few hundred cultures are being handled, it is possible to give each one individual attention. This means the culture can be inspected daily, if necessary, and a decision made as to how best to treat it. Should any problem arise it can be easily detected by the experienced eye and appropriate action taken. However, when hundreds of thousands of cultures are involved, the process becomes considerably more difficult. Systems must be devised which allow very large numbers of cultures to be progressed through the various stages of development with the most economic use of labour. Unfortunately, the response to treatments such as root induction varies considerably between cultures of the same clones, as well as between different clones. The system currently in use involves the maintenance of populations of "embryoid" and "rooting" cultures and the regular "harvesting", as it were, of shoots and rooted plantlets. The system relies heavily on the skill and experience of the "harvesters" and is continuously under development.

The control of infection of cultures has proved a difficult problem. Again, when only small numbers of cultures are being handled by a well trained, experienced worker, considerable care can be exercised. When very large numbers of cultures are being handled daily, the very high standards of hygiene and sterile technique required, are hard to maintain. The biologically dirtier environment of the tropics makes the task even harder.

The production process is currently, therefore, very labour intensive. This is a major factor in the high cost of the tissue-culture produced oil palm plantlet. If the clonal plantlet is to be competitive with seed, so that it is available to the smallholder as well as the large plantation company, production cost will have to be reduced. Looking to the future, therefore, some degree of automation may have to be introduced. With better control of embryogenesis, it should be feasible, for example, to grow callus in liquid suspension culture on a large scale, to induce large numbers of embryoids which might even be encapsulated, to produce an "artificial" seed.

Such ideas are currently under investigation, as are other areas such as protoplast culture, which may be needed if novel genes are to be introduced into the oil palm, and genetic fingerprinting. This technique will allow us to detect any genetic changes occurring during the culture process and will also give us the means of positively identifying a clone. This will be essential if the concept of patenting plants, as has happened in the U.S. recently, is generally accepted.

But before any of these "futuristic" ideas become reality, the basic concept of improved performance through clonal propagation must still be proved. Today, our theories on ortet selection, on just which characters can be reproduced in the clone, still have to be fully investigated. We have some evidence that, for example, certain bunch characters are inherited by the clone, but that environment has a strong influence on FFB yield even within a clone. Only the long process of field-testing of many more clones, rather than the handful now in the ground, will allow us to answer these questions. We now have the means to produce clonal oil palms, we now need to learn which ones to produce and how best to use them.

AN OVERVIEW OF A COMPANY NEWLY INVOLVED IN TISSUE CULTURE

J. Kanagaratnam*

INTRODUCTION

Sime Darby began work on oil palm tissue culture in early 1981. Early work was carried out via a liaison with an overseas commercial laboratory during which initial cultures were established.

Early work locally was carried out in a converted chemical store, with a single transfer-hood. The first cultures that were put in during this period were from root tissues; from which we have now three embryogenic lines.

Work on present facility with a floor space of 2,100 sq ft started in May/June 1983 and became functional in August 83. The area was made up of one large transfer room, two growth rooms and one media preparation cum washing area. The present facility is being currently doubled in size to cope with our production plans of producing 100,000 plantlets by the end of 1987.

TECHNIQUES

All the possible explant materials starting from embryos and seedlings as juvenile material and root, leaf and inflorescence tissue from mature palm have been tried out.

In initiating the explants, we found that all explants could be inoculated with a minimum amount of sterilisation except for root tissue. The time needed for callusing to occur was fastest with root tissue, embryo and young seedling. Leaf tissue and inflorescence took about 3 – 4 months to callus.

Callus was initiated on a high auxin media and allowed to divide and increase *en masse*. Once cell organisation begins, it being identified by the presence of modular structures the callus is moved to a medium with a lower hormone concentration to induce embryoid development.

The control of embryoid induction is not well understood but it appears to be related to the age of the starting material. Embryogenesis has been observed to occur when callus was placed on a medium with a reduced or zero auxin concentration.

Once embryoids have developed they can be induced to multiply and form more embryoids or they can be induced to form a shoot and root system and become a plantlet. In our system that we are using currently, shoots are isolated and allowed to elongate till they reach a certain size after which they are put onto a rooting medium. Once plantlets have reached a certain size, they are transplanted into the soil.

We have detected some problems with the pathway that we are using. One major problem is that some callus lines and embryogenic lines tend to brown rapidly. We have found that we can overcome the problem to a certain extent by putting them through a more frequent subculture

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cycle. However this is labour intensive and a better alternative needs to be worked out. Some embryogenic lines tend to be more prolific in the production of embryoids and shoots compared to others. A more frequent subculture again helps but we are looking into media optimisation to overcome this problem.

Abnormal shoot development in the form of inflorescence development has also been observed, at a very level of 0.6% at one time. This has now dropped and we are currently investigating the possible reasons to it.

PLANTLET ESTABLISHMENT IN NURSERY

Plantlets from the test tubes are moved directly into soil in polybags placed in a high humidity environment. Once they are sufficiently established they are moved out into the main nursery under partial shade and then subsequently transferred to big polybags when moved to the main estate nursery.

CONCLUSION

With extra space that is being created as a result of the extension, we will be actively putting into culture selected ortets to suplement our existing 195 embryogenic lines. Clones produced from the embryogenic lines will be field tested in the near future.

CURRENT STATUS OF OIL PALM TISSUE CULTURE AT IRHO

L. Baudouin *

I.R.H.O. began research on oil palm vegetative propagation in 1970, in collaboration with ORSTOM. The first plantlets were obtained in 1976, and since that time, the technique has been continually improved.

A laboratory of 250m^2 space was built in 1981 at La Me (Ivory Coast). Since that time 170 palms have been put in culture. The results obtained from these cultures are the following.

Year	No. of ortets sampled	No. of ortets giving calluses todate	No. of ortets giving embryoids todate
1981	41	39	27
1982	28	all	22
1983	37	all	23
1984	29	all	11
1985	35	(all after 3 months)	4
total	170		87

By the end of 1984, 3 clones produced polyembryogenic cultures. At the end of 1985, there were 18. Seven clones were produced at Bondy, from which two from adult palms can be added to this figure. The ability to produce embryoids rapidly depends on the origin of the material, and Deli x La Me are generally easier to clone.

The production of plantlets was 36,000 in 1985 and is estimated to reach 50,000 for 1986. These plantlets will be planted in six countries from Africa, South America and Asia to be tested in different environments and to promote the clonal materials.

At La Me Research Station, 18 ha. or 2610 clonal palms have already been planted. A total of 28 clones are represented, from which 18 have more than 50 ramets per clone. 18 clones will be planted in 1986 and 20 in 1987.

I.R.H.O has been working also on the cryopreservation of embryoids in liquid nitrogen. Plants regenerated from such embryoids will be planted in 1987.

* I.R.H.O. France

JOINT DISCUSSION
SESSION B

Chairman

Is there anybody who would like to kick off with any question or observation on this? I wonder if we can get PORIM to give us a more specific indication of how many clonal lines they have got? They have described how they have what they define as a clonal line which in fact may be a little more tight than most of us have. Perhaps, that must be borne in mind.

Paranjothy

We have almost a hundred of these polyembryogenic clones. Approximately half of these belong to collaborating agencies. Our strategy in cloning is not restricted to selected mature palms. There will be a lot of discussion, I am sure, in the afternoon, particularly about the necessity to stick to selected mature palms. This might seem to be the obvious route but the obvious route is not necessarily always the most feasible route. Nevertheless, we used a spectrum of materials. We spent 90% of our work on selected mature palms. We also used selected crosses in the form of big polybag seedlings and also very young seedling materials. Half of these belong to collaborating agencies. We have more than a dozen clones derived from selected mature palms. The rest are from crosses and there is one particular cross which has provided us with well over 30 clones. Now this is very useful from the geneticist's point of view. He can do quite a lot of interesting experiments given this type of material.

Soh

Breeders are somewhat different from tissue culturists involved in cloning. They are always interested in variation, whether they are useful variation or abnormal variation. I would like to express the concern that perhaps we, or somebody, should pay a bit more attention to variation arising from tissue culture. To some people, tissue culture is a mutagenic treatment. I have witnessed some so-called abnormal palms or clones in Africa as well as in this country. But they have been attributed to either because they came from unselected materials or because they were due to the early cloning processes which were perhaps not that well-refined, which gave rise to some of these abnormal palms. But it should perhaps concern us that if that thing can be seen on a macro level, we will also be interested to see if there are anything on a micro level which we cannot detect in the lab or in the nursery. Perhaps some more concerned bodies like government institutions should look into this aspect in terms of perhaps running some electrophoresis to look at enzyme differentiation of changes in patterns of what Ms. Wooi suggested, DNA fingerprinting to see if there is any likelihood of genetic variation induced by tissue culture.

Chairman

That's a fair point I think. The people who have got the oldest palms in the field produced from tissue culture, might possibly be able to throw some light on this. Is there anything you can say about that, Ms. Wooi? About the relationship of the ortet to the ramet basically.

Wooi

We have so far only about two years yield data from ramets planted in the field and there is some degree of similarity but with two years data, there is not much sense we can make out of it to

compare back with the ortet. We are still collecting data on the ortet presently because all the data we have were from pre-weevil times whereas now the ramets in the field will be post-weevil. So we still have to collect more new data before we can make any more conclusion.

Chairman

So as far as you can tell at the moment there is some similarity anyway.

Wooi

Similarity in terms of oil to bunch. We accept it as comparable to the ortet. Whereas as for the other characters, I am not in a position to further elaborate on that.

Yap

I just want to direct a question to Mr Kanagaratnam. As we know, normally for tissue culture we hope to identify the ortet plant or a very promising plant. But when you use a seed, I don't know what is the advantage for using tissue culture on the seed because you don't know the performance. What is the basis of doing that? No doubt it is very easy.

Kanagaratnam

The basis of our work was that the seeds that we used are from selected crosses and on the average they will perform better than the normal seedlings. Based on that fact, we have put a large number into culture. What we are doing is that we are just not taking normal commercial seeds but we are taking selected crosses which are known to be a little better than your average planting material. The clones that are going to be produced from these seeds, from the seed system, are then going to be field tested. We will definitely find variation but we will be able to identify the better yielding clones and then go back again and proceed to produce more clones from those lines.

Yap

Then under that situation, I might as well use normal progeny-tested material rather than using that.

Kanagaratnam

True, but the normal progeny tested material is a little bit more difficult to tissue culture. Anyway, even the clones from progeny tested material which are going to be produced will still have to be field tested. We will still have to field test whatever clones we produce.

Yap

I know. I mean the usefulness of tissue culture is not fully exploited, that is when one uses the seed. That's my thinking. I don't know about other people.

Chairman

I think the point missed here is that if you get outstanding seed families you can't necessarily reproduce them in large number by the normal seed propagation method. Whereas if you make a large number of clones from seeds, and you have to field test the clones anyway, whether they are from selected field palms or whether they are from genetic trials or wherever they are from, some of them are going to be outstanding presumably by the law of averages and those are the ones that you subsequently propagate. In other words, you are using field-tested clones. You can't do that with seedlings.

Tan, S.T.

I would just like to follow up on Dr Yap's comment. We are aware of what we call the risks involved but we are casting our nets wide. So we know that we probably will throw out a lot of the stuff but probably not all. I have a question here for Ms Wooi and that is based on conventional practice. Is there any culling in your ramets at the nursery or at any stage?

Wooi

Whatever culling we do is in the laboratory itself and that would depend as I spoke just now on the harvesters. You have to select for the correct type of material and of course there are some reject cultures, which do not meet your selection criteria, do not get transferred. And in the nursery we find that because we have done it before the plants leave the lab, there is very little, or hardly any culling at that later stage.

Tan, S.T.

What is the percentage at the lab?

Wooi

It is about less than 1% in the lab itself.

Ismail Hamzah

Presently, the only method of obtaining plantlets from the callus is through adventitious organogenesis. Now Ms Wooi has mentioned the possibility of encapsulating the embryoids when they are in free-cell suspension cultures. What is the present status of this free-cell suspension culture technique as far as the oil palm is concerned? The latest that I know, Unilever had performed such cultures and there was no report, presently, to say that embryogenesis in free-cell suspension culture is feasible.

Wooi

That is true but that was one of the ideas we mentioned for the future. It is under investigation for other crops and perhaps if you can control embryogenesis better than we can at present, then perhaps we can look into automation just to cut down the labour intensiveness of the whole project. But as far as suspension cultures in oil palm, you are right in saying that there has not been much progress in this area.

Soh

We have in our audience Dr Raju from the Central Plantation Research Institute of India who is the one responsible for working out the direct embryogenesis in coconut and he has done similar work on oil palms. Perhaps we should get another perspective of the process.

Raju

I was mainly working on the coconut and I was getting this somatic embryogenesis directly from the tender leaf explants. Last year, towards September, I thought I would try with oil palm too and I found that I was getting callus from the leaf explants from three year old palms and the calli that were produced were limited to the lower cut end of the explant. And when the callus produced was about three to four cell layers thick, I transferred it to the second medium where I got the embryogenesis. And these embryoids, are different from what I have seen in PORIM and HRU in that the embryos were formed from single cells and they would fall off into the medium after maturation, that is, at the end of the culturing, we can just shake the leaf explant that we put into the medium so that all the embryoids produced would fall off into the medium. Afterwards, these embryoids could be transferred for shooting or for further development or the second possibility is that it can be put for further multiplication by the process of budding.

Chairman

You actually have got plantlets up to how far?

Raju

I started last September and by this March I got the plantlets and now they are in the soil.

Chairman

It is quite fast and you can get a large number from. . . . .

Raju

From the leaf, the maximum number which I have got was nearly 30. And they ware found to multiply in the medium for embryogenesis. But there is one thing which I want to study again. That is whether there is any micro-callus formed in the process of budding.

Chairman

It sounds quite an interesting development. Are you going to continue to do this work? You have got the technique and we have got the oil palm, as you might say.

Raju

Actually I started this work because I wanted to standardise the method with coconut with this specific medium. I wanted to see whether this particular medium is suitable for other palms too. That is how I landed up with oil palm.

Chairman

I am sure PORIM, among others, will be interested to keep in touch and see how you are getting on with this.

One of the points that occurred to me from Dr Paranjothy's paper was that this genotypic variability to cloning success. Do you think this is partly because of the media you used and that possibly the genotypes, which do not respond particularly well to current medium might respond better to others and vice versa.

Paranjothy

I do not know the answer to that question. It is very difficult at this stage to say whether it is the genotype which is the primary factor influencing the embryogenesis or whether it is the medium. By and large, we use a variety of media for each genotype, well I should say for each batch of materials that we think can be put into the category as a genotype. These kinds of experiments seem to suggest that perhaps it is the genotype rather than the medium that is important.

SESSION C: BREEDING AND SELECTION STRATEGIES

STRATEGIES IN BREEDING AND SELECTION FOR OIL PALM CLONES

A.C. Soh*

INTRODUCTION

Many of you are already familiar with my recent paper (Soh, 1986) on this subject. What I intend to do today is to reiterate the salient points of this paper and to add to it some further thoughts and information.

In this talk I intend to demonstrate that the broad sense heritability (h^2B) for oil yield in our current DxP materials is low. This implies that the yield improvement with clones derived from these materials is expected to be lower than the 30% popularly presumed. More importantly the low heritability implies the unreliability of ortet selection and that extensive clonal testings are very essential. I will then discuss the implications involved in terms of current alternative selection and cloning strategies and future breeding and selection strategies. Lastly I will say very briefly in passing the use of clones in genetic experiments reserving further comments, if any, for a later session.

BROAD-SENSE HERITABILITY AND SELECTION RESPONSE

Broad-sense heritability comes to play when selecting plants for cloning. Broad-sense heritability values were computed from four Deli D x AVROS P trials. Deli D x AVROS P materials were chosen as the reference population because I consider them as representative of the most advanced DxP seedling material in terms of oil yielding ability planted in large acreages currently.

As you can see h^2B values are generally low averaging 0.19 (*Table 1*).Consequently selecting the top 5% or 1% by individual selection or by combined family and individual selection as commonly practised, will give an average expected response of only about 13% or so.

At this juncture I would like to bring to your attention to the high h^2f values and their consequent expected response to family selection which is nearly equal to those of combined selection. This will have bearing on our subsequent discussions.

It can be argued that the selection response of 13% computed is the average performance of the selected clones and that individual clones may achieve the 30% increase suggested. The probability of this occurring can be computed. We know that we can achieve a 13% increase by selecting the best family. Then knowing the genetic variance within family *i.e.* $h^2w \times \sigma^2w$, we can compute the probability of occurrence within the best family of the palm which exceeds the trial mean by 30%. As evident (*Table 2*) the probability is rather small, generally much less than 1 in 100. The palm would be rather unlikely to occur in a family whose size seldom exceeds 64 palms.

A logical progression from this analysis is to ask: Can we not then select based on a secondary character, logically a yield component *e.g.* O/B, which is perhaps more heritable and highly genetically correlated to oil yield, which would then bring about a better indirect response in oil yield? I did a very preliminary analysis, on O/B in one trial.

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Presently, Applied Agricultural Research Sdn, Bhd., Sg. Buluh.

TABLE 1. BROAD-SENSE HERITABILITY ESTIMATES FOR INDIVIDUAL (h^2), BETWEEN FAMILY (h^2f) AND WITHIN FAMILY (h^2w) SELECTION

Trial	h^2	h^2f	h^2w
B72-T2	0.14	0.78	0.08
B73-T3	0.14	0.79	0.08
B74-T4	0.20	0.86	0.11
B75-T6	0.25	0.86	0.14

TABLE 2. SUPERIORITY OF BEST FAMILY MEAN OVER TRIAL MEAN IN OIL YIELD AND PROBABILITY OF INCLUSION OF PALM WITH 30% SUPERIORITY OVER TRIAL MEAN.

Trial	Superiority of best family (%)	Probability of including palm with 30% superiority
B72-T2	11.5	0.0004
B73-T3	12.1	0.0001
B74-T4	12.7	0.0014
B75-T6	17.3	0.05

TABLE 3. RELATIVE EFFICIENCY OF INDIRECT SELECTION FOR OIL YIELD BY SELECTING ON OIL TO BUNCH.

Broad-sence heritability of oil to bunch (O/B)	h^2_B = 0.16
Genotypic correlation of o/B to oil yield	r_G = 0.56
Correlated response	CR = 4%
Direct response	R = 8%
Relative efficiency	RE = CR/R
	= 0.5

The h^2 B was 0.16, in fact lower than for oil yield which was 0.2. The genotypic correlation of O/B with oil yield was 0.54, consequently selecting indirectly on O/B, was only half as efficient as selecting directly on oil yield.

What about combining oil yield and one or more yield components in some form of selection index? Combining with O/B, with its low heritability, would be of no advantage. I am looking into combinations with other traits but I am not too optimistic. For one thing, selection indices or indexes are computed from genetic covariance or correlation estimates which are rather imprecise (Falcones, 1967).

What about basing on physiological traits such as bunch index (B.I) and mitochondrial activity as suggested by other workers (Breure & Corley, 1983, Kouame & Noiret, 1982). The problem with B.I. is that in the competitive seedling environment, or mixed stand if you like, heritability of B.I. is very low and it is probably negatively correlated with yield. The only way to ascertain its presumable physiological advantage which would be in a pure-stand, is by clonal test. We have yet to undertake such an experiment. Similarly, we have yet to resolve whether increased mitochondrial activity is the cause or effect of palm vigour and productivity and whether genetically superior palms out-competed by their neighbours will still exhibit high mitochondrial activities.

Low heritability means poor correspondence between the phenotype and its genotype and leads to unreliable ortet (adult palm) selection. Furthermore, the heritability and selection response estimates computed earlier were derived from a presumably competitive seedling or mixed stand and would thus apply to the case if the clones are planted in a mixed stand as the seedlings. The estimates would probably not apply as the clones will probably be planted in monoclonal blocks or pure stands. As such clonal testing becomes absolutely essential.

ALTERNATIVE SELECTION AND CLONING STRATEGIES

In the light of these and the current experiences in cloning palms there is a good case to be made for the following selection and cloning strategies which place more emphasis in capturing the best family performance. This is more likely to be achievable than on capturing the best ortet performance:

i) Cloning the D and P parents of the best families and producing biclonal F1 DxP seeds.
ii) Cloning all the adult palms within the best DxP families.
iii) Cloning the recreated seedlings of the best D x P families.

All three methods would give an expected yield improvement of at least 13%.

The disadvantage of the first method is the uncertainty of cloning the few palms involved. The advantage of methods (ii) and (iii) is that one can reconstitute the family performance with a small number of individuals. And if the tissue-culturist can assure us that there is minimal risk of somaclonal variation or genetic variation arising from tissue culture, we can even start selling them without prior clonal testing. Further yield improvement can subsequently be made by selecting the better clones after clonal testing.

The advantage of using seedlings (or even embryos) is that with less explant material per seedling used coupled with better cloning efficiency more palms can be sampled and this increases the chance of obtaining superior clones.

FUTURE BREEDING AND SELECTION STRATEGIES

The forgoing discussions pertain to the current status of the breeding and commercial DxP material available and our ability to clone palms. Optimistically we can expect our cloning ability to be further improved, and clonal propagation whichever form it takes, will feature significantly if not prominently in commercial oil palm planting material production. Breeding programmes drawn up will have to take this into consideration.

There are currently two principal breeding and seed production schemes practised which are: the modified recurrent selection scheme (MRS) and the modified reciprocal recurrent selection scheme (RRS).

In the MRS scheme the dura mother palms are selected on family and individual performance while the pisifera's being female sterile, are selected initially on their tenera sib performance and confirmed subsequently by DxP progeny test. This scheme emphasizes general combining ability.

In the RRS scheme, however, both the dura and pisifera parents selected are from the selfs of the respective D and T grandparents which combine well in the DxT progeny test. The scheme embodies a recurrent phase to improve a particular hybrid combination as well as a recombinant phase to broaden the genetic variability. As evident, this scheme emphasies specific combining ability.

Our earlier results revealed the low genetic variability between palms which is a consequence of the narrow genetic base of the parental breeding populations and the high selection intensities necessarily practised. Future breeding programmes (*Figure 1*) should place even greater emphasis on outcrossings between palms of different genetic origins in the respective dura and pisifera populations to generate greater genetic variability and less emphasis on improvement in a particular hybrid combination by recurrent selection to exploit SCA, which can be shortcircuted by cloning. More DxT progeny testings in three or four-way crosses should be made to screen the combining abilities of the parental populations for further breeding and to generate superior combinations and individuals for cloning. DxP progeny tests and DxP commercial seed production involving pisifera sibs from promising TxT outcrosses and duras from DxD outcrosses can still be done while improvement in a particular hybrid type can be achieved through selecting the better combining pisiferas, by cloning the D and P parents of the best cross for biclonal F1 seed production or by cloning the re-created seedlings or ortets of the best cross.

The scheme I have drawn up will to various extent be adopted in most breeding programmes.

Reliable ortet selection will still be a problem because of the large environmental variance, which can be attributed largely to inaccurate records and interpalm competition effects. The advantage of selecting ortets from three or four was DxT crosses is that genetic variation between palms will presumably be larger enabling more effective selection. Some confidence in ortet selection can be assured if the selected palm possesses superior more heritable yield components *e.g.* M/F and if it is less vigorous and does not enjoy special environmental advantages than its neighbours. Accurate yield records can be assured by taking longer yield records and additional and perhaps more elaborate O/B samplings. Honestly I do forsee many of us doing these, the extra effort could perhaps be better channelled towards testing more clones.

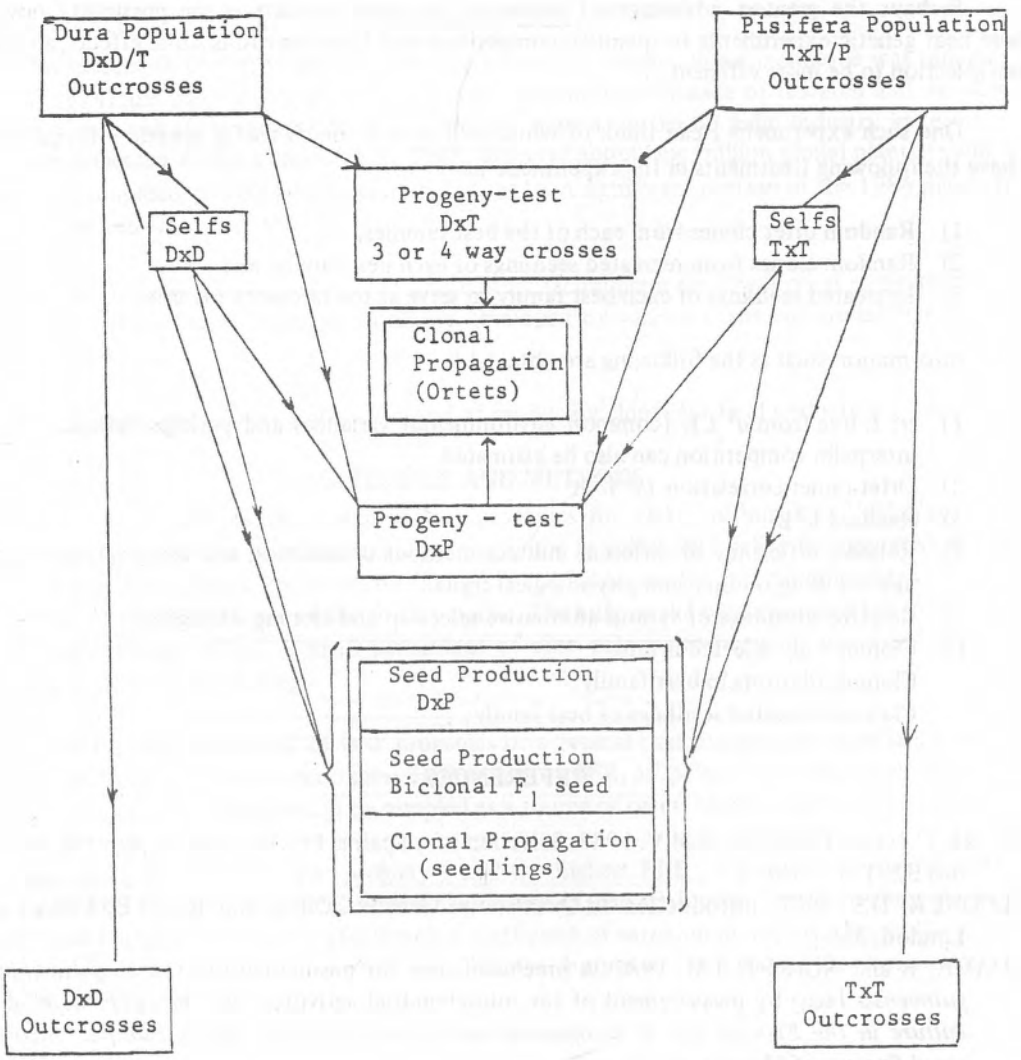

Figure 1. Outline of Expected Future Oil Palm Breeding Scheme

Interpalm competition in oil palm can be rather intense. Quantification and adjustment for competition effects will assist in ortet selection. One way is to seek a relationship between a palm and its neighbours in some growth or productivity parameter.

Perhaps the greatest advantage of clones to oil palm breeders is the possibility now to devise neat genetic experiments to quantify competition and other environmental effects, enabling palm selection to be more efficient.

One such experiment I can think of which will provide much useful genetic information is to have the following treatments in the experiment *i.e.*

1) Random ortet clones from each of the best families.
2) Random clones from recreated seedlings of each best family, and
3) Recreated seedlings of each best family to serve as the reference material.

Information such as the following are obtainable:

1) σ^2 E free from σ^2 CE (common environmental variance) and perhaps variance due to interpalm competition can also be estimated.
2) Ortet-ramet correlation *i.e.* h^2B
3) Realised h^2B
4) Relative efficiency of different indirect methods of selection and using various combinations of agronomic and physiological traits.
5) Relative advantage of various alternative selection and cloning strategies.

i.e. Cloning only selected ortets.
Cloning all ortets in best family.
Cloning recreated seedlings of best family.

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A RAPID METHOD OF DEVELOPING OIL PALM CLONES

N. Rajanaidu*

INTRODUCTION

The success of vegetative propagation of oil palm by tissue culture technique was reported by Jones (1974) and Rabechault and Martin (1976). Even after a decade of research and development, the tissue culture technique has not made any impact on the oil palm industry in terms of supply of commercial planting material. In 1986, however about one million clonal plantlets will be produced as compared to 100 million germinated seeds. A significant portion of the 1986 plantlets is probably derived from embryos.

One of the major problems of the tissue culture technique is the low level of embryogenesis. This, in turn, determines the number of clones developed by various tissue culture laboratories in the world.

In this paper, we suggest a quick method of producing clones for field evaluation.

MATERIALS AND METHODS

At present, the breeders screen various progenies for yield, oil/bunch, oil/palm/yr, stem height, oil characteristics, and other secondary characters to select elite palms for vegetative propagation. Basically, the selection is based on family mean. Subsequently, outstanding individuals are identified in the best family as a source of elite palms. The bulk of the ortets are selected from families with high average values. A small percentage of elite palms also occur in mediocre families. These too are selected for cloning.

Table 1 shows the list of 25 DxP progenies of a typical trial and analysis of variance shown that there are significant differences between families for FFB, oil/palm/yr and oil/bunch. The elite palms within the top few families can be sampled as a source of ortets based on yield.

Taking FFB as an example, progeny *9* had the highest FFB yield of 231 kg/palm/yr. The trial mean is 198.8 kg and the best family is 20.1% higher than trial mean. Within the best progeny the yield could range from 192.7 – 260.9 with a coefficient of variation of 10.75%. Normally, about 60 palms per progeny are planted in the field. The distribution of the yield of the best progeny is given in *Figure 1*.

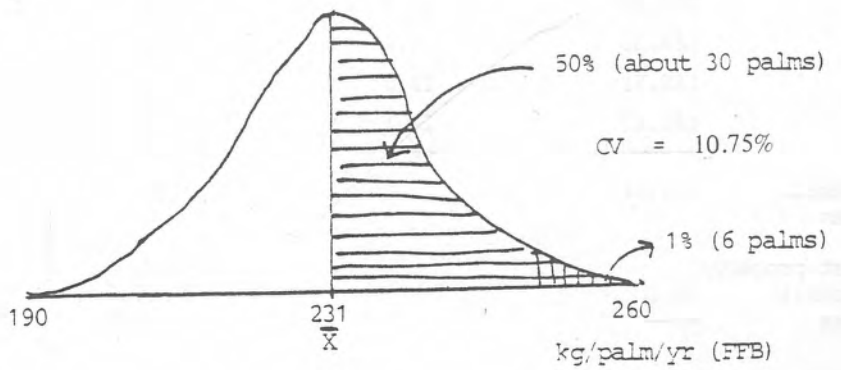

Figure 1. Distribution of individual palm FFB yields within the best family of a DXP trial.

* PORIM, Bangi.

TABLE 1. PERFORMANCE OF PORIM DXP PROGENIES TESTED AT HIGHLANDS RESEARCH UNIT, KLANG.

Progeny	FFB/palm/yr (kg) (mean of 4½ yrs)	Oil/bunch (%)	Oil/palm/yr (kg)
1	197.48	27.2	53.6
2	167.62	26.2	52.2
3	219.72	26.0	56.4
4	181.46	23.8	44.7
5	207.19	23.9	49.7
6	203.20	24.0	52.8
7	188.88	23.9	43.0
8	187.71	24.9	47.6
9	*231.49	25.9	58.7
10	187.78	28.8	55.5
11	186.43	25.0	48.8
12	216.51	25.2	49.4
13	209.92	26.8	*59.1
14	192.35	22.5	41.4
15	169.03	29.3	49.5
16	211.61	23.1	53.4
17	169.42	25.4	43.2
18	183.74	22.2	49.1
19	174.82	24.9	47.6
20	196.19	27.4	54.8
21	192.66	25.5	52.3
22	206.95	27.3	56.7
23	189.35	24.4	48.9
24	188.51	22.3	44.9
25	160.47	24.1	44.0
Overall mean	192.81		50.2
Best progeny/ Block (%) mean	20.1		17.7

TABLE 2. THE NUMBER OF SEEDLINGS (CLONES) (n) REQUIRED TO CAPTURE THE MEAN OF THE ELITE CROSSES TESTED IN THE FIELD FOR THE CHARACTER – OIL/PALM/YR (kg).

Progeny number	$\bar{x}$	CV (%)	No. of seedings per progeny	Confidence Interval (D %)	n
1	39.05	11.65	64	5	16.21
2	45.59	19.17	64	5	30.64
3	43.14	15.67	64	5	24.34
4	41.29	17.00	64	5	26.84
5	44.33	20.53	64	5	32.84
6	36.12	20.35	64	5	32.56
* 7	47.27	16.46	64	5	25.84
8	43.43	14.85	64	5	22.74
9	36.10	14.35	64	5	21.75
10	40.56	20.76	64	5	33.19
11	43.43	17.73	64	5	28.16
12	43.30	15.59	64	5	24.19
13	40.11	16.68	64	5	26.25
14	42.70	19.65	64	5	31.44
15	40.35	16.63	64	5	26.16

Ideally, it is economical and rewarding to sample top 1% (say 6 elite palms) of the best family, provided it is possible to clone all the selected palms. However, in practice, the success rate of embryogenesis for mature palms is low, slow and unpredictable especially with root explants. Usually about only 10–20% of the elite palms selected are amenable to embryogenesis. Hence, 1% selection intensity may not yield any clone at all. Alternatively, it is possible to clone all the palms above the family mean, say about 30 elite palms and with 10–20% embryogenesis rate, 3–6 clones may be developed for clonal evaluation.

In view of the above limitation, we suggest the use of *elite crosses*. It is worthwhile to recreate a known high yielding DxP progeny and use the embryos of these seeds for the production of clones. *Table 2* shows the mean performance of 15 DxP progenies. Earlier studies had shown significant differences between these families. The table also shows the number of clones required to capture the mean of the original progeny. The following formula (Cochran, 1968) is used to compute:

$$n = (4 \times CV \times CV \times N)/(D \times D \times N) + (4 \times CV \times CV)$$

Where:

CV = Coefficient of variation within a progeny (%)
N = Number of palms observed per progeny
D = Confidence interval (%)
n = Number of clones required to capture the mean of the original progeny

For example (see *Table 2*), to capture the mean of progeny 7, we have to develop at least 26 clones from its recreated cross. Since the CV within progenies is very low, *i.e.* about 16%, it is unlikely that much improvement can be realised by further selection within the 26 clones. The above method can be exploited further. Theoretically, the mean performance of the 26 clones could be close to the performance of the elite cross number 7. Therefore, it is possible to release these 26 clones in a group to the industry for commercial planting without field evaluation; provided there is no adverse mutation or variation arising from tissue culture.

Similarly, instead of embryos, leaves of young seedlings of recreated crosses could be used. Apparently, explants (roots, leaves) of young seedlings are more amenable to callus initiation and embryogenesis.

The above method of using seed embryos could reduce the scale of operation considerably at the laboratory level. For instance, about 2000 root/shoot samples are collected from each of the selected elite palm. For 30 palms of an elite progeny, 60,000 (30 x 2000) root/shoot samples are assembled in the laboratory. In the case of embryos, only 100–200 samples are required because each embryo could give rise to a clone without much difficulty.

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BREEDING AND ORTET SELECTION STRATEGIES IN FELDA AGRICULTURAL SERVICES CORPORATION

Chin Cheuk Weng*

INTRODUCTION

The strategies for ortet selection at FELDA Agricultural Services Corporation are based on the advice given by the I.R.H.O. While they reflect the I.R.H.O.'s strategies, it must be made clear that they do not necessarily represent the official I.R.H.O's selection strategies. The information given here is specifically tailored for FELDA's strategies.

BASIC SELECTION STRATEGIES

(1) Priority to identification of the best oil producing progenies from progeny trials.
(2) Identification of progenies with slower growth, and also with good oil production.
(3) From progenies selected in (1) and (2) above, identify superior palms which have consistently (*i.e.* without widely fluctuating yearly FFB production) superior yields and oil production. Secondary characters to look for are slower height increment and less vegetative matter.
(4) Checking these palms and keeping only those palms which are not unduly affected by environment (such as next to vacant palms, or next to the road). Such palms are selected as ortets, after sufficient bunch analyses have been completed.

SELECTION OF PROGENIES

From statistical analysis and using the Duncan Multiple Range Test, it is possible to identify the best oil producing progenies. Other progenies which are retained include those with high variability and slower growth, but which still give good oil production.

GUIDELINES FOR PRELIMINARY PALM SELECTION

(1) Retain palms which have FFB yield above the mean of the selected progeny in the trial.
(2) Retain palms which have height increment less than the mean of the selected progeny in the trial.
(3) Discard palms which have mean crown radius very much above the selected progeny's mean crown radius.
(4) Retain palms with good bunch analysis data
(5) All preliminary selected palms are field checked to confirm their suitability. Normally about 20% of the palms in a selected progeny are available for field checking.

CHOICE OF PALMS AS ORTETS

For palms without bunch analyses, two bunches have to be analysed and if the results are homogeneous and good, further bunch analysis will be carried out for confirmation.

For palms with some bunch analyses, the homogeneity of the analysis data is checked. If homogeneous, a field check will be carried out to confirm whether those palms are to be selected

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as ortets. If not homogeneous, more bunch analyses will be carried out, provided the palms are retained after the field check.

Before confirming a palm as an ortet, the most important factor to consider is its ability to produce excellent oil yields.

BREEDING STRATEGIES WITH A VIEW TOWARDS ORTET SELECTION

New material has to be generated through breeding programmes. This can be achieved in a number of ways:–

(a) DxT and DxP progeny testing using material from various sources, such as Yangambi, La Me, NIFOR, AVROS for the male parents and duras from Serdang, Kulai, Ulu Remis, Banting for the female parents.

(2) Recombination programme for the best progenies and parent palms.

(3) Breeding for clones involving wider crossing, some sort of "F2" from "F1" x "F1" crosses, combining high yielders with different complementary characters. As many palms of the "F2" are planted so that extreme individuals which combine the desired characteristics of all parents can be selected.

ACKNOWLEDGEMENT

The author wishes to thank the General Manager of FELDA Agricultural Services Corporation for permission to present this paper and to Dr. Soh Aik Chin of Highlands Research Unit for his criticisms on the paper.

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A METHOD FOR CORRECTING SOIL HETEROGENEITY TO ESTIMATE GENOTYPIC VALUE FOR THE SELECTION OF ADULT ORTET PALMS IN OIL PALM EXPERIMENTS

L. Baudouin*

INTRODUCTION

The aim of the plant breeder is to estimate the genotypic value of his selected plant with the highest possible precision. To meet this purpose, he tries to eliminate the effect of environmental influence on the phenotype. The classical way to achieve this is to plant replications of the same genotype in some definite arrangement.

This method is, of course, not applicable to the choice of ortets among mature palms. However, it is possible to improve the precision of the choice by introducing a correction factor that accounts for the fertility of the soil at each point of the field.

METHOD

The procedure described below was developed to give an optimal estimation of this correction factor. It comprises four steps:

1) In the case of a genetic trial, it is necessary to eliminate the variations arising from differences between crosses. This is done simply by dividing the value of each palm by the average value of its cross.

2) Then the semi-variogram is calculated. This function which value is given by the formula

$$V(h) = (1/2N_h). \sum_{1} [(F(x_i + h) - F(xi)]^2$$

where N_h is the number of couples $(x_i, x_i + h)$ of palms separated by a distance h associates variance and distance between palms. *Figure 1* indicates the principal characteristics of a theoretical semi-variogram. Here, V_p represents the semi-variogram of the phenotype P which can be considered as the sum of two factors A and B:

A is a random variable, independent of the position of the palm. It includes all genetic factors and some environmental factors. As A is purely random, its semi-variogram is a constant V_A. V_A is sometimes called "nugget effect".

B is a certain (non-random) function of the geographical location of the palm in the field. It can be identified with the fertility of the soil at this point. Its semi-variogram is V_B (Note that $V_B(0) = 0$, because B is non-random). By hypothesis, A and B are independent and V_P is the sum of V_A and V_B. There are different models of semi-variograms corresponding to different structures of variability. The presence of an horizontal branch in *Figure 1* indicates that the fertility of the hypothetical field is homogeneous on a large scale, but presents "patches" of variations with an average size close to the range R.

3) Now, we are looking for B, the best estimate of B, that is the value of B that minimises the error variance:

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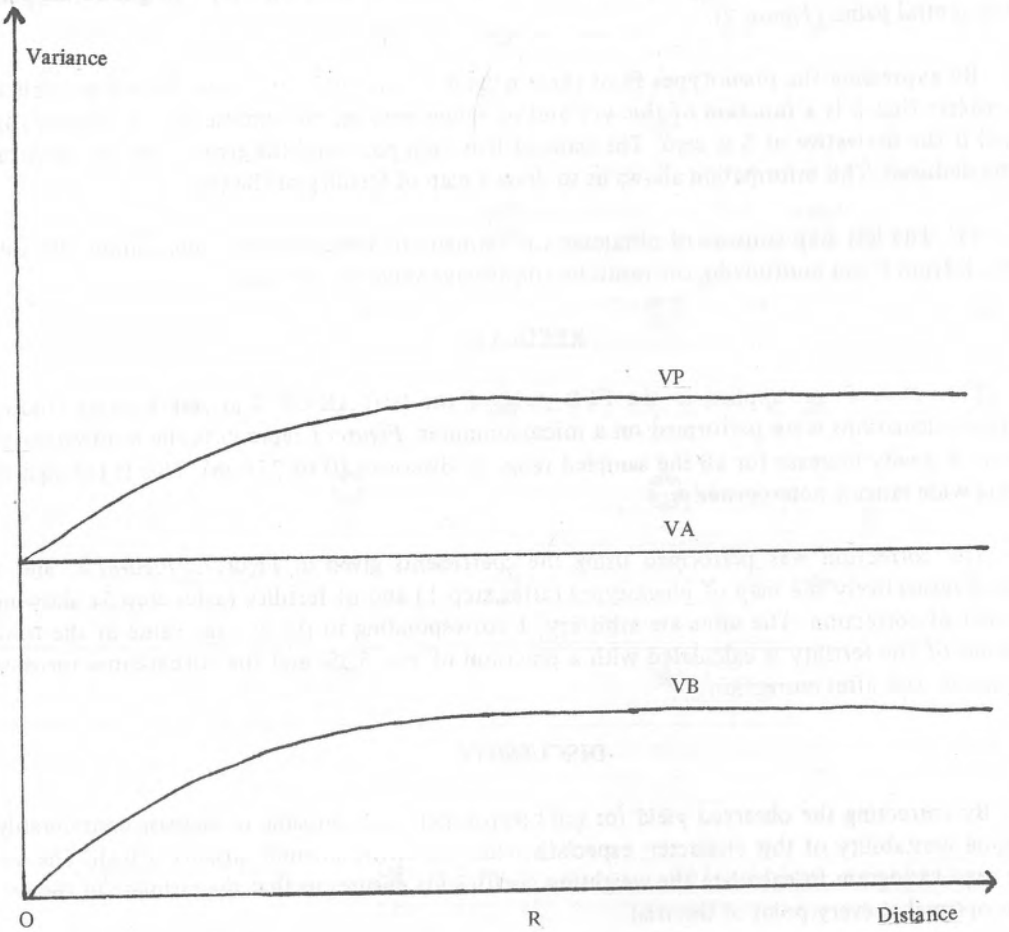
* I.R.H.O., France.



VP : Semi-variogram of P (between palm variance for any distance)
VA : "Nugget effect" corresponding to the random variation factors (including genetic factors).
VB : Semi-variogram of B (describing the variations of fertility)
R : "Range" of the semi-variogram (corresponding to the average sizes of heterogeneities).

Figure 1: Example of a theoretical semi-variogram.

for any B, $S(B) \leqslant S(B) = E(B - B)^2$.

The general form of our estimate is a weighted average of the value of surrounding palms, $B = \Sigma\ wjPj$ where each weight wj depends only on the distance between the j^{th} neighbouring palm and the central palm. (*Figure 2*).

By expressing the phenotypes Pj of these neighbours in terms of Aj and Bj, it is possible to demonstrate that S is a function of the wj's and of values read on the semi-variogram. The wj's are optimal if the derivative of S is zero. The value of B at each point and the error of the estimate can then be deduced. This information allows us to draw a map of fertility of the trial.

4) The last step consists of obtaining the estimate of the genotypic value, simply by subtracting B from P and multiplying the result by the average value of the cross.

RESULTS

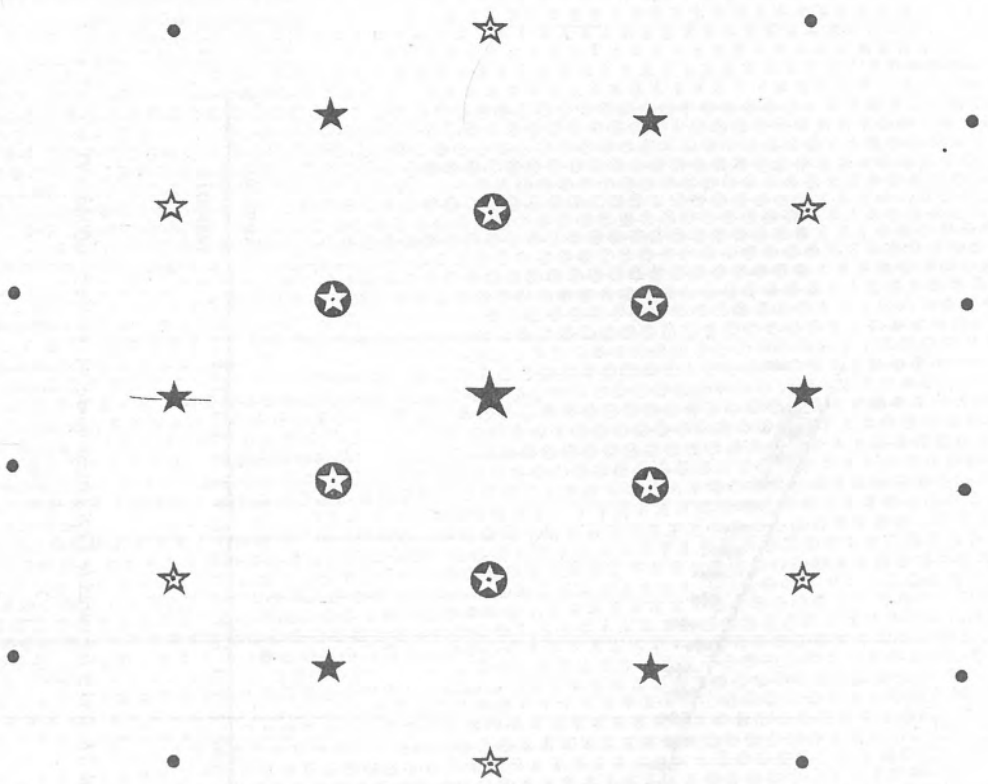
This method was applied to the FFB yield of the trial AK-GP 3 in Aek Kwasan (Indonesia). The calculations were performed on a microcomputer. *Figure 3* represents the semi-variogram. It shows a steady increase for all the sampled range of distances (0 to 255 m). This is the sign of high and wide ranging heterogeneity.

The correction was performed using the coefficients given in *Figure 2. Figures 4* and *5* represent respectively the map of phenotypes (after step 1) and of fertility (after step 3), showing the effect of correction. The units are arbitrary, 1 corresponding to the average value of the trial. The value of the fertility is calculated with a precision of +/– 5.2% and the within-cross variance decreases by 48% after correction.

DISCUSSION

By correcting the observed yield for soil heterogeneity it is possible to increase considerably the actual heritability of this character, especially when the environmental variance is high. The use of the semi-variogram to calculate the weighting coefficients ensures us that the estimate of the fertility is optimal at every point of the trial.

This method can be applied to other characters as for example height growth. It would be also a good way to approach problems of genetical and environmental correlation.



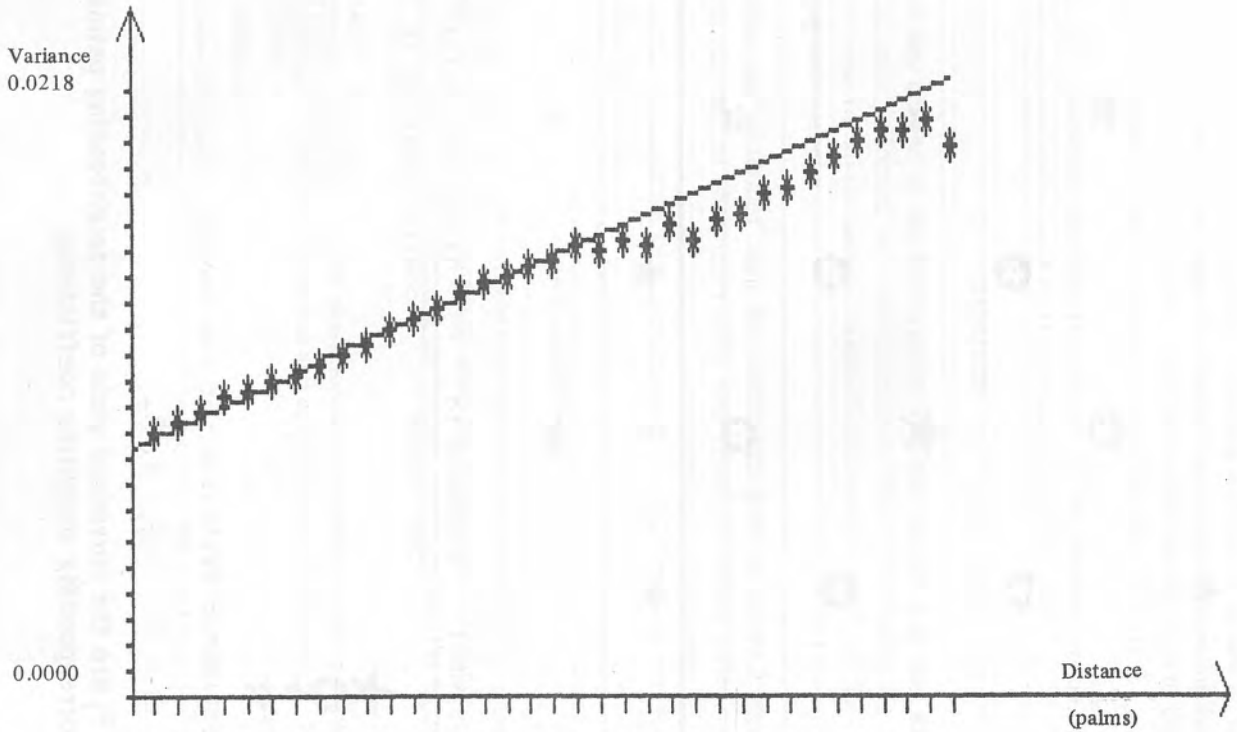
Legend :	Symbol	Distance to the centre	Calculated weighting coefficients in AK GP 03
A	★	0	$w_A = 0.07246$
B	✪	1	$w_B = 0.05615$
C	★	1.732	$w_C = 0.04995$
D	☆	2	$w_D = 0.04850$

The estimated fertility of the central palm is equal to :

$$F = \sum_{j=1}^{19} w_j . P_j$$

where the P_j are the corrected yield of the neighbouring palms and the w_j is the corresponding weighting coefficients.

Figure 2. Ponctual estimation of the fertility



N.B. The between-palms spacing is 9 m.

Figure 3. Semi-variogram of trial AKGPO 3 for variable FFB Linear model: V = .0095 + .0004 x D.

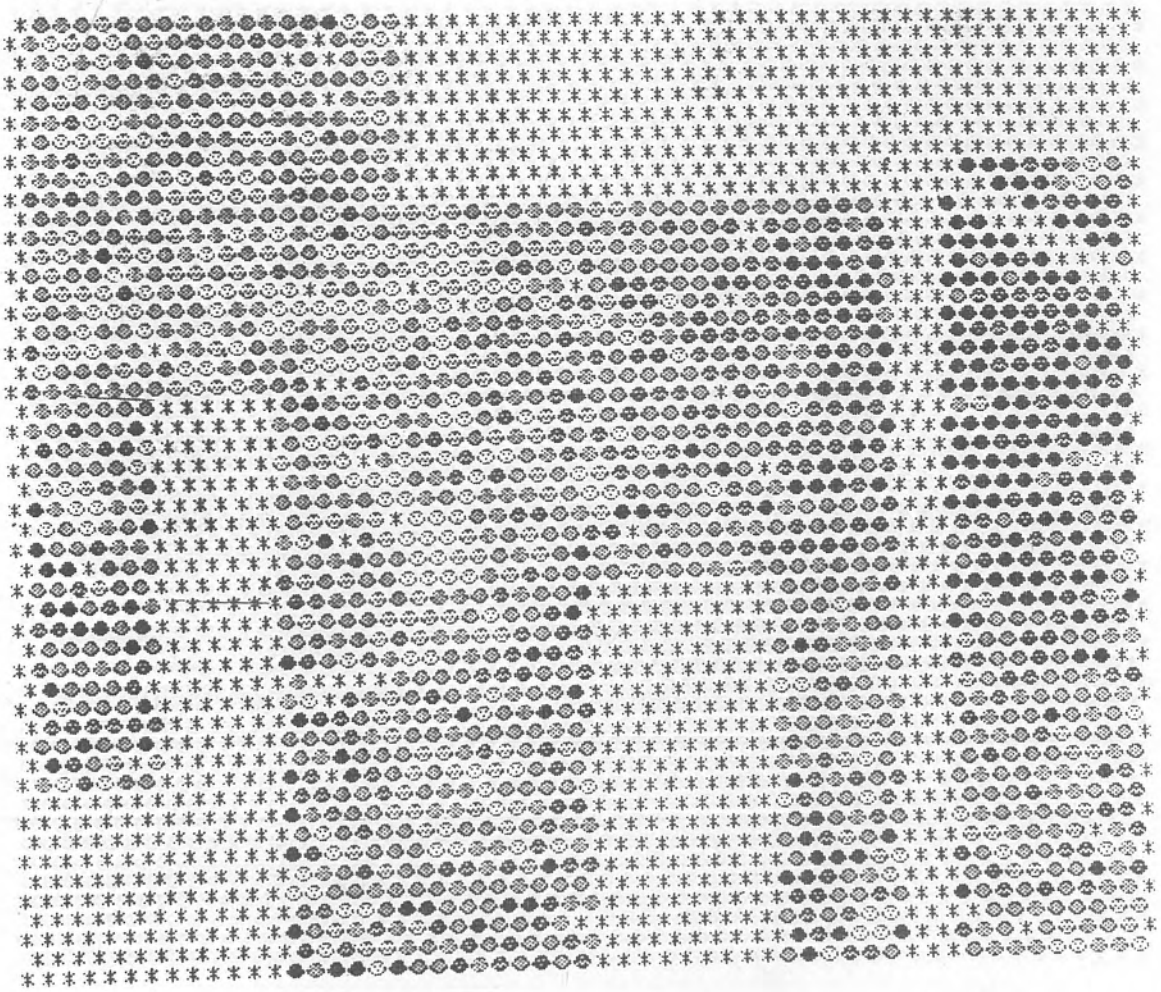


Figure 4: Map of adjusted production in AK GP 03. (before smoothing).

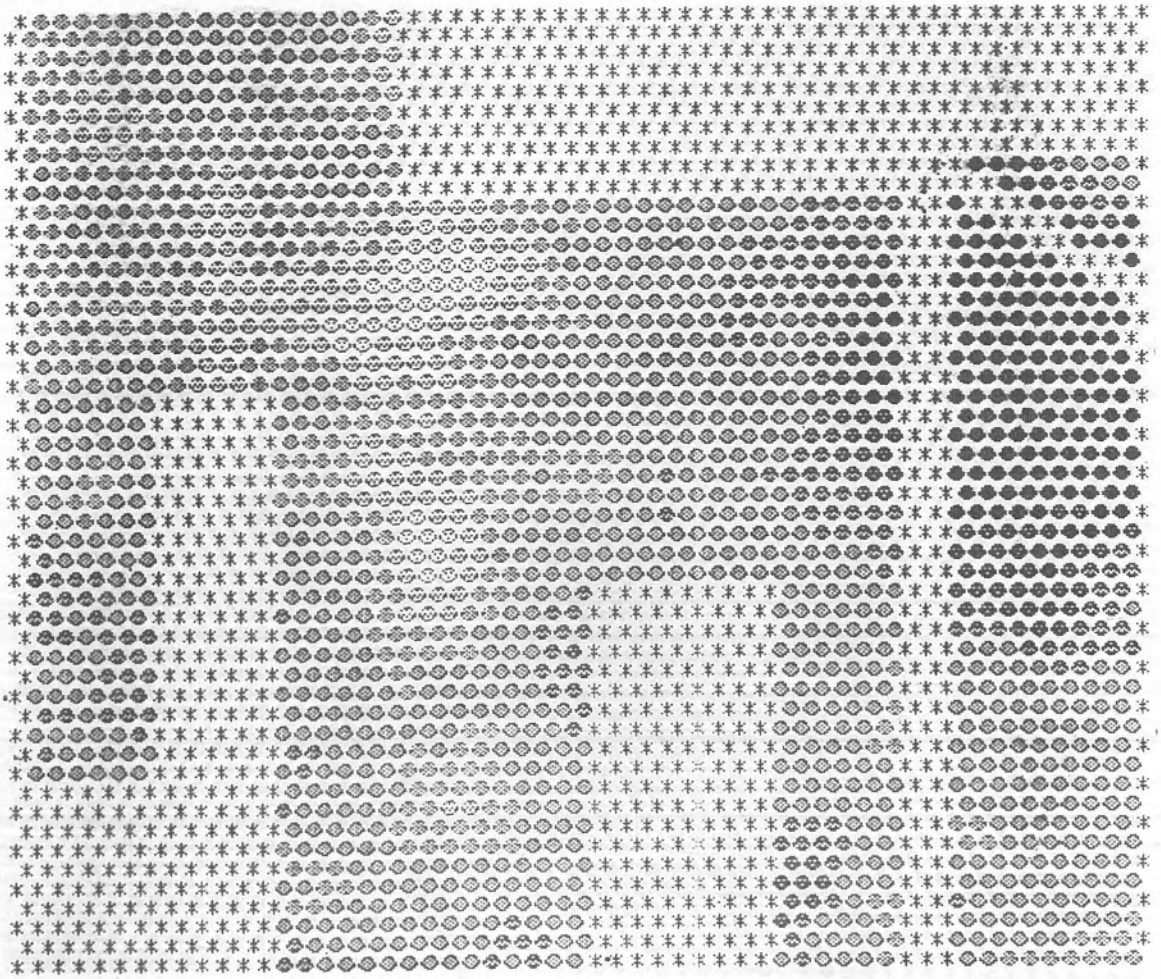


Figure 5. Map of Fertility in AK GP 03 (after smoothing)

JOINT DISCUSSION
SESSION C

Chairman

Has anybody anything they would like to say?

Baudouin

Dr Soh told us of the choice of palms which are less vigorous than the neighbours. What are the criteria which are more important to us?

Soh

Actually it is more of observation than anything else. If a particular palm chosen, based on the results, are high-yielding and yet is not more vigorous than its neighbours, in terms of height and crown cover as what Mr Chin has said, then the chances are that it is a good palm that will perform well in a community of this sort of palms.

Boudouin

What particular characters do you think are more useful besides the height?

Soh

They are the size of the crown i.e., the structure of the canopy in terms of the weight of the petioles or fronds and the coverage as well.

Rao

A question for Dr. Soh Aik Chin. A point made by two of the speakers was the emphasis that perhaps we should be looking to clone elite progenies. One of the things that seem to me is that much of the work with elite progenies, at least as far as I know, is done where these progenies have also been subjected to a certain degree of culling. Thousands of seeds are produced per cross but at germination at the nursery, culling is practised in some cases even deliberately to get the best seedlings that estates require to go to the field. To what extent will our results, our choice of these so-called best progenies being biased by this kind of inadvertent culling.

Soh

I think if you ask most plant breeders, they don't believe that most of the culls or so called runts in the nursery are really due to genetic problems involved as much as managers or nursery people would like to call it. I don't think the really genetically deformed materials are going to be more than 5%. A lot of the symptoms that you see in the nursery really can be induced just by doing very simple experiments like withdrawing water and that sort of thing. Secondly, even if you have about 5%, if you clone about 30 or so palms and you are still doing some initial raising of the material in the nursery, if they are really runts you would have picked them up. Especially runts in a clone will come out very clear cut.

Rajanaidu

As far as PORIM is concerned, we don't make any culling at all in our progenies, especially at the time of planting in the nursery. In fact, we deliberately do this for our progeny trials especially to avoid this kind of biasness.

Arasu

My question also relates to the question of cloning seedling material. I think given the relative ease of propagating materials from seed tissue or embryo tissue one can see the advantage of cloning material from the right embryos. And also given the low heritability of most of the traits that we are interested in and therefore the resulting need for testing the clones, perhaps there is no great disadvantage in cloning seedling material but when one talks about recreating superior families I think one has to give quite a bit more thought in defining what these superior families are for the purpose of selecting clones. To take the example that was given by Dr Rajanaidu where he had these outstanding families with high yield in the field but with a C.V. of around 10%, one wonders what advantage one is going to get from clonal propagation of individuals selected from such a family, and whether one should really go for families such as that or look for other families with much greater variability within themselves, so that one hopes to capture not just the family mean but also the superior variance from within the family.

Rajanaidu

We want to recreate the best progeny and at least quite a large number of clones from the best progeny whose mean is at least 20% more than the trial mean for immediate release to the industry, without field evaluation, of course provided there is no mutation in the clones due to the tissue culture technique. The objective is to release immediately this group of clones for large scale planting where we can realise at least 20% more yield than by planting large number of D x P crosses of different levels of yield, not for selecting clones further within the 26 clones.

Soh

I will just follow up on that. I think the point brought up by Dr. Arasu is very logical. If you have a material that is very variable you have to sample much more and you have to test more. The other thing that I brought up is to reconstitute the family performance. Well, we can compute the sample size to recapture the family performance. The only way I differ from Dr Rajanaidu is that he uses the phenotypic CV, I tend to use the genotypic CV and the numbers will be smaller, about half.

The other thing too is that you can compute the chances of capturing the palm with a certain quantum above the best family mean and also statistically the sample size involved. So if you want a higher quantum or to capture the palm with a higher quantum jump then you have to have a larger sample size.

Chan

This is a follow up of what Dr Arasu has said. From the earlier papers, we have heard however that there are genotypic differences in response to cloning. So in this respect there should be concern that the progeny population cannot be created absolutely, because selection pressure during tissue culture will actually favour those progenies which are easier to clone. So in this sense, genetic drift

is expected to occur, and it will be most unfortunate if there are any of these correlations which exist between ease of cloning and poor yield. So how do you reconcile this?

Soh

I think the point is well taken except that we don't have any information at the moment. So the only way is to test it out.

Chairman

Surely the organisations with clones long in the fields must have some idea by now whether there is any indication that there is a correlation between clonability and low yield, even if you are not prepared to give any more details on that. Say yes or no to the general question.

Wooi

I think Mr Yong from our organisation is in a better position to answer that.

Chairman

Basically, it has been suggested that it is not yet established that there is no correlation between clonability, if you can use such a term, or ease of cloning and low yield. Possibly these genotypes which clone easily also have low yield. And I said that although no doubt specific answers couldn't be given, in general terms Unilever might be able to answer that because they have had clones in the field longer. At least tell us whether they are showing the tendency to yield very poorly or anything like that.

Yong

I don't think we have any data to confirm whether there is any correlation between clonability and the yield.

Chairman

You have to be careful because you might be leaving an impression that all your clones are yielding very poorly.

Yong

I mean we don't have any specific data to confirm whether there is such a relationship.

Chairman

There must be general indication of whether there is such a relationship or not. Are you saying that there is no indication of whether there is such a relationship? You are saying there isn't such a relationship probably.

Yong

I think the yield data that we have so far is only about two years and we haven't got very much data from the ortets.

Chairman

Have you got very much yield from them?

Yong

Actually we have got about 75% yield increase over the conventional D x P over the first one and a half years of yield results.

Chairman

That would seem to answer the question but it probably isn't a specific correlation between low yield and clonability. It does not seem to give an indication.

Lee

Just to follow up from what Mr Yong had said. We are not in a position to say whether cloning ability is correlated to yield at the moment mainly because we have only the results from four main selected clones or four clones from selected ortets at the moment. In subsequent years, probably we will be in a better position to tell. We have about nearly 20 clones, I believe, from selected ortets and from early indications, although it is a bit premature to say at the moment, some of these selected clones, from selected ortets, do not really indicate that they are low-yielding. Actually I want to say this part in a later session but since you brought it up. But anyway, we have no indication at the moment as it is that cloning ability has got anything to do with low yields or high yields, except that we have got clones which are definitely higher-yielding than current D x P.

Chairman

There is no doubt that is as far as we can answer that question at the moment. I think the question is not whether it is what you call a straight line correlation between clonability and yield or something like that. The question is simply, "Is it only poor yielders which clone easily?". The answer seems to be no.

I would like to ask Dr Soh one question, if I may. I am not too sure about this initially projected 30% yield increase. Can that be achieved straight away just from your first set of clones or was it said that it could be an ultimate goal after you field test the clones?

Soh

The 30% was a magical figure which has been floating around. I am not responsible for that figure. As far as I know, it was derived from a particular trial. They just plotted the distribution of individual palm yields over a two year period. If you take 5% from there, you would be sure to get a mean that is greater than 30%. To get a 30% increase, actually I did say in a paper I published, you have to assume a very high broad sense heritability.

Chairman

Was that figure actually as you said it was vaguely floated around. Was it not said that you could go to a palm which is outstanding and clone it and be sure of getting 30% yield increase, surely there was indication that there was that much variation and with proper programme and development in selection you might go for that level.

Soh

As I said, the figure came from a particular D x P plant planted in Malaysia I presume. The reason why I did this paper was just to cross check this because we use the same materials when we plotted the phenotypic distribution and we computed the broad sense heritability and we see how much likely is the genetic response, if you pick up the top 5%.

Chairman

The point is that you are not saying that after a programme of planting clones and field testing them you still aren't going to be able to achieve the 30% yield increase or are you saying it?

Soh

What I'm trying to say is that with the materials that you are having, it is not likely that you are going to achieve figures of that magnitude. They will probably revolve around the 13% I was talking about. And as I have said, the values we computed were actually from a mixed seedling stand and what it will perform in a pure stand is actually still not quite certain.

Tan S.T.

I have a question for Dr Soh. The 30% that was floating around earlier, are the materials the same as yours, all the four trials?

Soh

I presume they were.

Tan. S.T.

Because all your four trials are Deli x AVROS so they may be more uniform.

Soh

That's right. That was the whole idea of this exercise. Most of the advanced material we have here are very uniform.

Neoh

Dr. Soh, how possible is it to establish pure lines of D and P, as you know in the subsequent crosses to maximise the F1 vigour? I say this because genetic materials-wise, your D and P are vey much different.

Soh

I think you are very influenced by the experiences in the annual crops such as corn, and in oil palm because of the long generation time, you are not in a position to go to the route of developing true inbred lines and testing them until the end. So the closest that we could get is actually the scheme that is proposed by the IRHO. But even then, after two selfings they move out because usually after two selfings the palms will be very difficult to reproduce. The question of whether there is so-called heterosis or not, I think, is still under contention between the French and the so-called other schools.

Yap

I have a question for Dr Soh. It seems to me, if I understand correctly, you are not promoting people to exploit the specific combining ability in oil palm breeding. But it seems to me that what the oil palm industry have today actually is a hybrid variety and for developing hybrid variety specific combining ability is very important. I don't know what is the basis behind it.

Soh

I think I am not saying that we are deliberately not selecting for specific combining ability, because if you look at the scheme that we have, it is not specifically for it. But if you pick the best family, well it could be due to the specific combination. You'd never know, it depends on how you design your experiments to show that there is a specific combining ability effect.

Yap

I think we should promote this because the specific combining ability is not exploited in our oil palm industry. All the time we were exploiting the general combine ability. The scheme that you proposed, recurrent selection for specific combining ability, I think, should be used.

Soh

In fact in the scheme which I have drawn, which is broadly based on the IRHO system except that I do not go to the next generation to improve the particular hybrid combination to be called exploiting specific combining ability. We do not have to do it by the breeding method. We could perhaps clone it. That was the idea, we could clone it if we can spot it in the D x P progeny test.

Yap

Right, if a very good parent has a very good specific combining ability with another then you can get the progeny and then you clone it.

Soh

Yes, it is in that scheme.

Yap

I want to direct another question to Mr Chin Cheuk Weng about your F2. Is this F2 a selfing or is it a cross of 2 F1's.

Chin

It's just a cross of two F1's.

Yap

Then it should be a F1 again not F2 otherwise it is misleading. It is a double cross but still F1.

Soh

To follow up on the last question by Profesor Yap, I have some remarks on this. Both Mr Chin and Dr Rajanaidu brought up this idea of crossing $F_1 \times F_1$, that is, you pick the best D x P palm and cross it with another one which complements each other in their characteristics. If you are a corn breeder, you are talking about a double-cross. And if you are talking about a double-cross, the best way to achieve maximum heterosis is to make the first cross between parents that are closely related and then subsequently outcross them. This is not the case which has been suggested. So if there is a heterosis you are not exploiting it to the fullest. Secondly I am not in favour of this method which is also proposed by the IRHO. You need a special progamme for it. It is not part of the main breeding programme. In this programme because you are trying to capture the so-called transgressive segregant so to speak, you have to have a very big family size. And then don't forget that your materials will be segregating out into duras, teneras and pesiferas. So you need a even bigger sample size or family size to pick out the best teneras individuals. All these efforts could actually be channelled in terms of space and time, towards the main breeding programme. Again, we can't use the so-called rapid regeneration method. Your materials may turn out to be duras teneras or pisiferas. So on these points, I am not too in favour of that scheme.

SESSION D: BREEDING AND SELECTION FOR CLONES IN OTHER CROPS

BREEDING AND SELECTION OF RUBBER CLONES IN THE RUBBER RESEARCH INSTITUTE OF MALAYSIA

Mohd. Noor A.G., Khoo S.K. and Naimah I.*

Research in breeding and selection in RRIM has played a significant role in developing new and advanced generation clones for the rubber industry. Since 1928, there is a yield improvement from 500 kg/ha/yr for unselected seedlings to 3,000 kg/ha/yr for the modern clones. It is observed that the yield increased rapidly during the early breeding phases but tended to slow down in the later phases of the breeding programme. The slow down is mainly attributed to the narrow genetic base of the available breeding population. However, with the introduction of new genetic materials, there should be scope for further yield improvement.

Rubber, being a perennial crop, has a long testing and selection cycle. The whole cycle, from crossing to recommending a proven clone to the industry takes about 30 years. All careful steps need to be taken because once planted, the trees remained for 25 to 30 years and can only be changed by incurring great costs in replanting. As such, it is very important that due care be taken in thoroughly testing the materials before release to the industry.

The literature of rubber breeding has been reviewed by Tan (1986) and Simmonds (1986).

BREEDING OBJECTIVE

The main objective of the RRIM breeding programme is to produce clones with high yield combined with good all-round secondary characteristics. These important secondary characters include:

- resistance to wind damage
- good vigour to reduce the unproductive immaturity period
- field resistance to major leaf diseases
- sustained good girth increment on tapping
- good bark qualities
- tolerance to tree dryness or brown bast
- response to low frequency tapping and chemical stimulation.

To combine high yield and the various desired secondary characteristics within a clone is most difficult to achieve. Hence, some compromises have to be accepted in their selections.

BREEDING AND SELECTION PROCEDURES

Breeding and selection of rubber involves a number of stages (see *Figure 1*). These are hand-pollination, nursery testing, small scale clone trial and large scale clone trial. In addition to the above conventional cycle, an accelerated programme using promotion plot clone trial was introduced in the late 1960s. To complement the production of clones through the hand pollination programme, mother tree/ortet selection in advanced generation seedling populations was also carried out. Some details of the above procedures are described below:

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Hand-pollination

Hand pollination is carried out with parent clones based on known phenotypic and if available, genotypic values.

Each year, several thousands of pollinations are made during the first and second flowering seasons. Pollination success is low, varying from 0 – 5%. The major factors affecting pollination success include severity to *Oidium* infection and weather conditions.

Nursery Testing

On harvesting the successful hand pollinated fruits, the seeds are germinated in polybags. These polybags are placed in a cage nursery to prevent damage from rodents. Germination success is normally about 80–90%. When the seedlings reach the three-whorl stage, they are then transferred to field nursery and planted at a spacing of 1.2 m 1.2 m in single family blocks. After two and half years in the ground, the seedlings would have attained a reasonable girth size of about 20 cm. They are opened for test-tapping using the modified Hammaker-Morris-Mann technique (Hammaker, 1914 and Morris and Mann, 1938). The tapping system used is ½S d/3 (half spiral, third daily). Test-tapping is done for three cycles and each cycle consists of 10 tappings. After each cycle, the latex coagula are collected, air dried for one month and then weighed. The yield of individual seedling is recorded and is expressed in gm/tree/cycle.

Selection of superior seedlings is largely based on yield, although vigour, branching habit and resistance to leaf fungal disease *e.g. Oidium* and *Colletotrichum* are also considered.

Small Scale Clone Trial

A certain proportion (5–20%) of the test seedling population are selected and cloned for field testing in small scale clone trial (SSCT). In SSCT, the plot size consists of eight trees in a row. The experimental design used is a simple lattice with two replications. The control clones used are normally the current popular Class I and II clones. At present these are RRIM 600 and PB 235 Girth measurements are taken annually at a height of 150 cm from the stock-scion union. The trial is opened for tapping when 70% of the whole trial area has attained a girth size of 45 cm and above. At six monthly intervals over the next two years, additional trees are brought into tapping when they reach tappable size.

Yield in the form of cup-coagula, is taken at monthly interval and is expressed in gm/tree/tapping. Selection of superior clones is made on the basis of two to five years yield data. Secondary characters as described earlier are also considered during selection.

From the SSCT, selections are made for further evaluation in large scale clone trials. Because of land and other resource constraints, the number of selections has to be small, not more than 10%.

Large Scale Clone Trial

Large scale clone trials can be likened to variety testing trials. They are geographically dispersed to test the adaptability of the new clones to a number of diverse environmental conditions throughout the country. There may be as many as 10 such trials within a set. The design used for these experiments is normally a balanced incomplete lattice with three to five replications. The plot size is approximately 0.2 hectare or 60 to 70 trees. A few standard clones of known performance are used as control or check clones in these trials.

The tapping system used in these trials is ½S d/2 or ½S d/3. Measurements taken during immature and mature stages are similar to those of small scale clone trials. However, in these trials, cup-coagulation is carried out only in recording trees leaving out one row of trees surrounding each plot serving as guard rows. Assessments of secondary characteristics are more or less similar to that in small scale clone trials.

Large scale clone trials are maintained up to 20 years and basing on their yield performance and secondary characteristics, the promising clones are selected and recommended to the industry.

Promotion Plot Clone Trial

Promotion plot clone trials (PPCT) were started in the late 1960's with the objective of shortening the long testing cycle. The very few elite seedlings from nursery test-tapping were cloned and established alongside large scale clone trials in similar size plots but with only one or two replications. This system by-passes the small scale clone trial stage and shorten the testing period by about ten years. Results todate are most promising (Ong *et. al.* 1985).

Block Planting

Block planting was introduced to establish promising speculative clones into the planting industry. Task-size plots of a few selected clones are planted out and the tapper's yield is monitored to compare the performance of these new clones under commercial conditions. This feed-back is extremely useful in assisting the upgrading of clones in planting recommendations.

Mother-Tree/Ortet Selection

There exists in estates large fields of PBIG/GG seedlings. The more promising ones come from GG 1, 2, 4, 5, 6, 7 and 8. These are actually advanced generation polycross seedlings derived from parents with high general combining ability. Mass selection was carried out on this population of millions of seedlings to provide materials to complement the conventional hand-pollination programme. The elite seedlings were cloned and tested in nurseries, small scale clone trials, promotion plot clone trials and large scale clone trials. Early results indicate that this approach would likely provide clones to the industry in the near future (Khoo *et. al,* 1982 and Ho *et. al,* 1979).

PROBLEMS AND CONSTRAINTS

In the efforts to meet the objectives of rubber breeding and selection programme, rubber breeders have to face many problems, and try to find possible solutions for them. These problems are as follows:

- low pollination and fruit-set success
- selection for multiple characters
- narrow genetic base of current breeding population
- long testing period, and
- genotype-environment interaction

Rubber breeders have embarked on various strategies to tackle at least some of the above-mentioned problems, *e.g.*

- modifying the technique of hand-pollination to increase fruit-set success
- widening the genetic base by introducing new *Hevea* germplasm from Brazil

- short-circuiting the testing cycle
- in-depth understanding on the inheritance nature of yield and related secondary characters, and
- refining the "Enviromax" planting recommendation approach

In the long term approach, breeders could perhaps explore new innovations to create new variability through induced mutation and polyploidy, and genetic manipulations in the distant future.

CONCLUSION

Malaysian rubber industry has survived for the last century and even with the present economic turmoil it is still considered an important one to venture into. It still remains the most important small-holders' crop affecting the well being of many lives. Its survival depends on productive and integrated research on breeding and other associated disciplines.

ACKNOWLEDGEMENTS

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BREEDING AND SELECTION OF CLONALLY PROPAGATED TROPICAL FRUIT SPECIES

Y.K. Chan, M. Zainal Abidin & Siti Hawa Jamaluddin*

ABSTRACT

The majority of perennial woody fruit species in the tropics can be propagated by asexual means. Besides reducing the period of juvenility, clonal propagation also allows the fixation of heterozygosity giving rise to homogeneous populations.

Breeding and selection of clonally propagated fruit species at MARDI is uncomplicated but the process may be of long duration. Four basic steps are followed i.e., *selecting the potential 'winners' from germplasms/fruit collections and at the farmers' fields, testing whether the 'winners' performance are repeatable over time and space in G × E trials, 'cleaning up' any other weaknesses of the selected genotypes using hybridisation and backcrossing and finally improving the performance of the clonal population as a whole through increasing planting density using dwarfing rootstocks and determining the composition of clonal mixtures in self-incompatible species (durian) so that the component clones are cross-compatible with favourable xenic effects for improving fruit quality and productivity of the clonal population.*

Work currently carried out in MARDI at these different stages for various fruit species are cited to illustrate the achievements of the breeding and selection programme for clonally propagated fruits as a whole.

INTRODUCTION

Malaysia has a rich heritage of indigenous fruit species and together with introductions which are readily adaptable here, the number of fruit species that can be cultivated in this country is tremendous. The majority of the woody perennial species can be clonally propagated by grafting and in some cases by air-layering and cuttings. The herbaceous, short term perennials such as pineapple and banana differ in the mode of vegetative propagation compared with the woody perennials in that whole propagules (suckers) are used. Among the woody species, mangosteen (*Garcinia mangostana)* and duku langsat (*Adlaia domestica*) represent two unique cases because seeds are apomitically formed (Kaur *et.al.,* 1978) and clones may be propagated by this means. Apomixis may be so widespread in mangosteen that it has led some to believe that cultivated mangosteens probably belong to a single clone.

Besides reduction in the period of juvenility in perennial species, clonal propagation allows the fixation of heterozygosity, giving rise to homogeneous populations within which the individuals are heterozygous in genetic constitution. Nothwithstanding environmental influences, the characteristics of the clone, particularly those qualitative in nature governed by single or few genes, are repeatable from generation to generation.

Breeding and selection of clonally propagated fruit species appears to be a rather uncomplicated task but it is often a long term process particularly for perennial species. The primary aim is

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to identify the 'winner', most times this being a single tree of outstanding quality and subsequently propagating the genotype from generation to generation by vegetative means. Related to this, however, two questions need to be answered. "Where would this 'winner' be most likely found?" and "Can this 'winner' repeat its performance, particularly for quantitative characters like yield which cannot be elucidated from the original maternal tree, over time and space?"!

These will be the two major areas which the paper will focus on. Some discussions on how to further improve the performance of the selected genotype by breeding methods, and the overall population's productivity through use of dwarfing rootstocks and in the case of durian, using compatible pollinator clones in clonal mixtures to improve fruit set and productivity will be made. These four essential steps in the breeding and selection of clonally propagated fruit species are summarised in *Figure 1*.

SOURCES FOR CLONAL SELECTION

Germplasm and fruit collections

Germplasm and fruit collections are two major sources where clonal selection can start. These two terminologies both have a similar function *i.e.*, assembling a range of accessions of the fruit species to provide the genetic variation vital to the breeding programme. The difference, however, lies in the nature and mode of collection of the accessions. In a fruit collection, the accessions are usually advanced breeding lines, varieties, cultivars or clones, the collection of which is non-random. On the other hand, accessions in germplasms are obtained at random from natural populations and in this respect, a representation of the genepool is emphasized.

The fruit germplasm of MARDI was initiated in 1982 in collaboration with IBPGR and only indigeneous species of economic importance such as durian (*Durio zibethinus*), rambutan (*Nephelium tappaceum*), banana (*Musa sapientum*), cempedak (*Artocarpus champeden*) and mango (*Mangifera indica*) were given emphasis. The number of accessions collected for the different fruit types is given in *Table 1*. All the materials were established at MARDI, Kemaman.

The fruit collection at MARDI, Serdang was initiated in 1972 and at the start, consisted of a duplication of the clonal materials registered by the Department of Agriculture. A significant portion of the clonal materials was registered way back before World War II, and antiquated though they may be, several of them *e.g.*, D2 and D24 durian clones had continued to be of major importance to the fruit industry today. More accessions were added to the collection from time to time, obtained from farmers' fields, fruit exhibitions, as well as from neighbouring countries. The present number of accessions in the collection for each fruit type is presented in *Table 1*. The collections of non-indigenous fruit types *e.g.*, ciku (*Achras sapota*), guava (*Psidium guajava*) and starfruit (*Averrhoa carambola*) are considerably smaller because of difficulties faced in introduction of these materials.

Characterisation and evaluation are important in germplasm and fruit collection work. They permit the breeder to take stock of the variability available for manipulation in crop improvement as well as to provide information for selection of the promising materials from the collection for further trials and evaluation.

This aspect of work has been fairly well accomplished for banana, mango and durian at MARDI. The description of the collection for a particular character is based on the distribution pattern of the accessions, the mean, range and coefficient of variation (CV). An example on the evaluation of earliness in fruit drop for the durian accessions in Serdang is highlighted to make a point about the importance of characterisation of the population in relation to selection for ear-

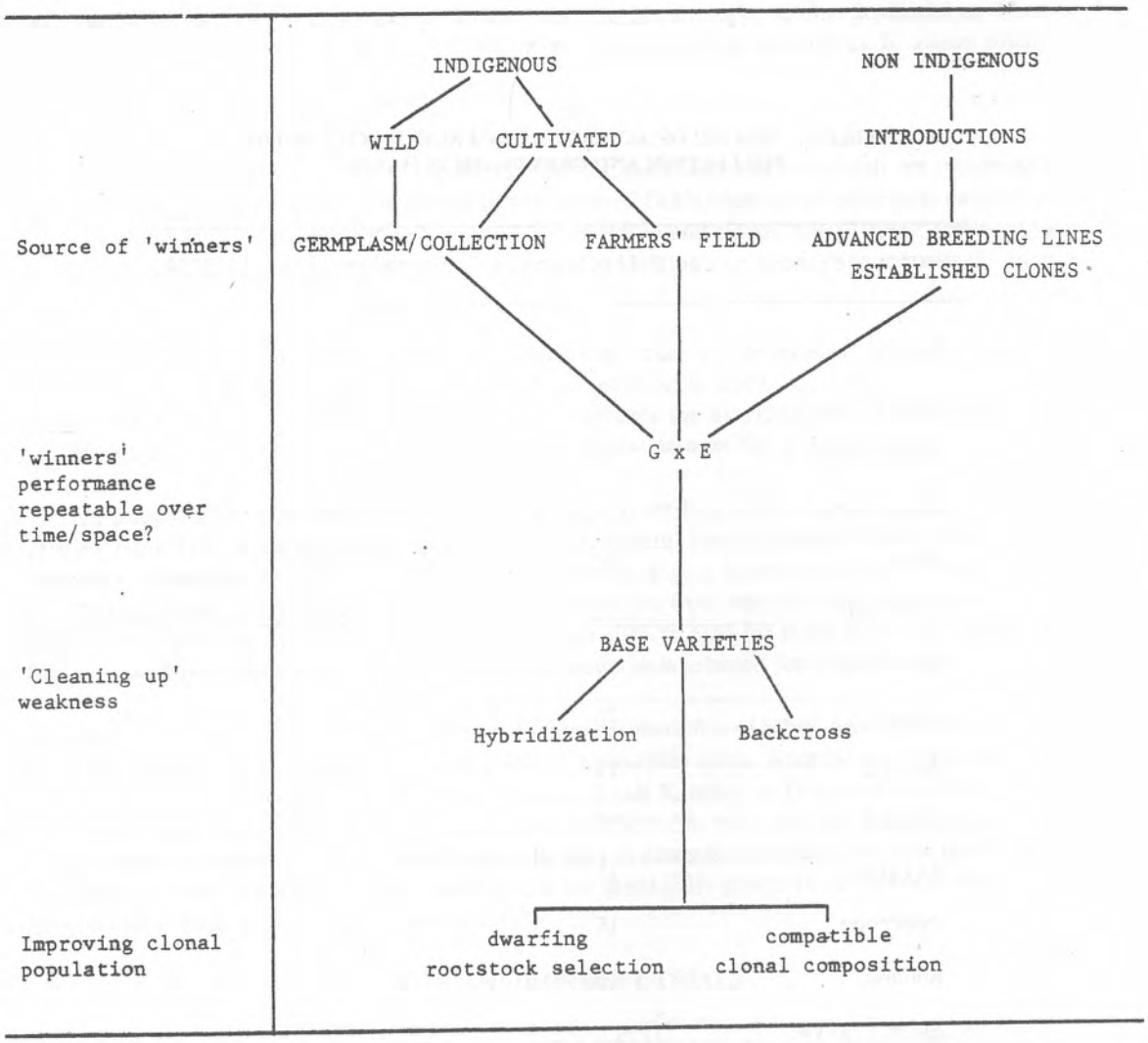

Figure 1. Schematic representation of programme for breeding and selection of clonally propagated fruit species.

TABLE 1. NUMBER OF ACCESSIONS BY FRUIT SPECIES IN THE COLLECTION AND GERMPLASM IN MARDI.

Fruit species	Collection	Germplasm (MARDI-IBPGR)
Durio	80	506
Nephelium	62	191
Artocarpus	30	30
Mangifera	111	259
Musa	140	17
Lansium	5	87
Garcinia	-	21
Ananas	75	-
Achras	14	-
Citrus	94	-
Psidium	17	-
Averrhoa	16	-
Annona	15	-
Rare Fruits		46

Data collected over eight seasons indicated that the accessions had a mean fruit drop of 111 days from anthesis with a range of 100 to 128 days and a CV of 50.2%. The population is skewed in distribution towards early fruit drop (*Figure 2*). There is wide genetic variation for this character and selection of accessions at the two opposite tail ends of the distribution will quite effectively extend availability of fruits by at least three weeks and this has strong economic implications. There are, however farmers who may prefer growing mainly D99 to catch the high early season prices.

Evaluation and selection at farmers' fields

Most of the indigeneous fruit species like durian, rambutan and cempedak are outcrossers and the existing stands of seedling materials in the farmers' fields (dusun) are extremely variable in nature. Exploitation of this rich natural resource for selection and clonal improvement appeared to be the most sensible thing to do. Selection for further evaluation can be made in a relatively short period of time.

Systematic recording of yield and fruit quality of trees in the farmers' fields over several seasons provides preliminary data upon which interim selection is based. A considerable amount of time is saved in this manner of evaluation because it obviates the introduction of these clones into the fruit collections in order to obtain a more or less similar data set for selection guide.

In selection of cempedak as an example, about 150 seedling trees with good potential were identified from five cempedak growing states *i.e.,* Terengganu, Perak, Selangor, Kedah and Perlis. Preliminary evaluation of fruit quality indicated that even with a biased sampling (choosing only the promising trees), the variation obtained was very high for fruit, seed and pulp weights and seed number. The CV of the selected population ranges from 30% to 60% for these characters (*Table 2*). Forty trees with promising fruit characters from this group were selected for further G x E trials.

For banana, phenotypic within-cultivar differences were found when accessions of the cultivar were collected from farmers' fields in different geographic areas. Accessions of "Rastali" for example, were so phenotypically different in Pontian, Kuala Kangsar or Dungun that environment alone cannot fully explain the large differences. Such differences can only arise from spontaneous mutation since no sexual mating between banana groups or accessions are likely to have taken place to account for such changes. That such differences are genetically governed is shown in the G x E trial on banana discussed in the following section.

GENOTYPE-ENVIRONMENT TRIALS

This is the most important stage in the overall breeding and selection programme for clonal fruits. As can be seen from *Figure 1*, all activities that generates preliminary selections *e.g.,* from the germplasm, collection, farmers' fields *etc.*, are linked to this penultimate step prior to recommendation of the variety.

In the past, a fairly large number of fruit clones such as D2, D10, D24 (durian), NSI (nangka (*Artocarpus heterophyllus*)), R134, R162 (rambutan (*Nephelium tappaceum*)), MA128 (Harumanis mango), MA162 (Golek mango), B10, B11 (starfruit) and C61, C62 (ciku (*Achars sapota*)), were recommended by the Department of Agriculture based on fruit quality only. Usually the evaluation was done on single tree basis with limited attention given to yield and its stability in performance over environments. Subsequently, in the list of recommended clones of various fruit types, little else was said about the clones other than a perfunctory description of the fruit quality. That such clones have unsurpassed quality is undeniable but the yield performance and stability should deserve as much scrutiny, if not more.

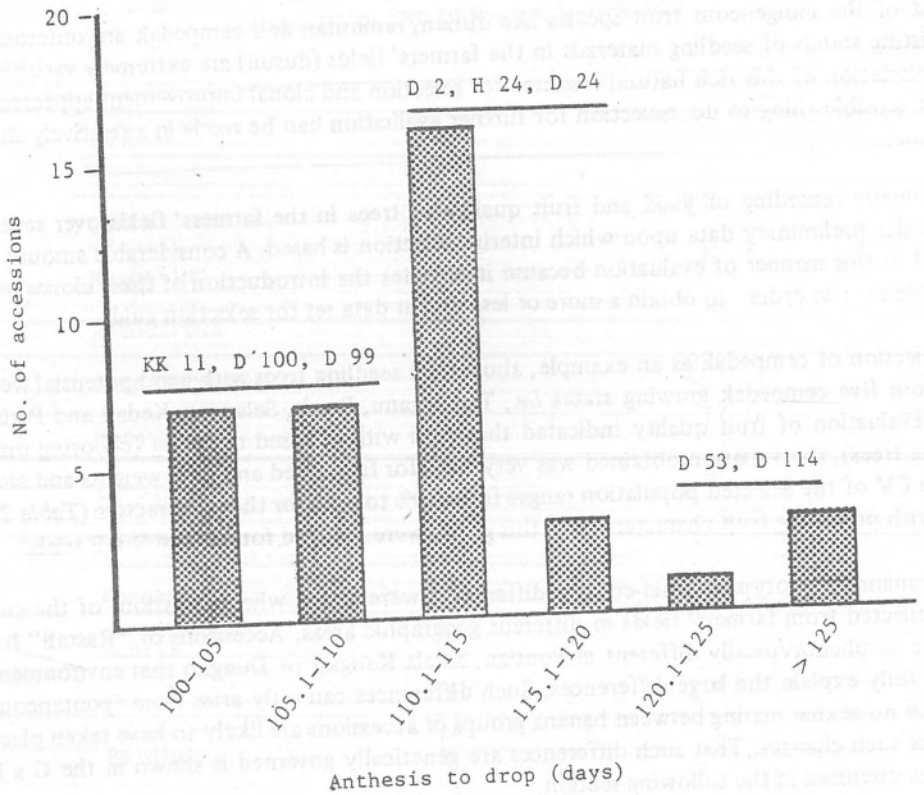

Figure 2. Distribution for earliness of fruit drop

TABLE 2. DESCRIPTION OF THE CEMPEDAK POPULATION SELECTED FROM FARMERS' FIELDS.

Characters	Mean	C.V. %	Standard Deviation	Range
Fruit length (cm)	36.92	18.10	6.6822	21.50 - 58.0
Fruit weight (kg)	2.70	45.87	1.2375	0.80 - 7.30
Number of seeds	62.31	59.86	37.2949	6 - 189
Pulp thickness (mm)	4.03	29.36	1.1827	1.80 - 8.00
Weight of pulp + seeds (kg)	1.42	56.15	0.7963	0.30 - 4.20

For this reason, in the breeding and selection projects of clonally propagated fruit types, all had an experiment on G x E testing, regardless of whether the materials were preliminary selections from the DOA register, collection or from introductions.

For banana, the G x E tests do not place emphasis on the difference in performance and stability between cultivars eg., between Mas, Embun or Berangan. For one thing, genotypic differences between cultivars are bound to occur but more importantly, the socio-preference for one particular cultivar of banana usually is so strong that farmers do not invariably change over to another cultivar just because it is 'more stable' or better yielding. Comparison of performance and stability between cultivars therefore, has little value.

G x E for banana is used for establishing genotypic differences and stability of accessions within a cultivar. In a recently concluded trial involving four Rastali accessions tested over four locations, the accession from Kuala Kangsar was shown to be higher yielding and consistently so over the other acessions. The good stability of this accession as well as 'Pontian' are shown by the slope of the regression which is nearly equal to unity as well as small deviations (SE) from the regression (*Figure 3*).

The G x E conducted over seven locations to test the performance and stability of the new Hybrid 1 pineapple (Nanas Johor), indicated that the new variety was more vigorous and had better fruit size than its contemporary commercial cultivars like Masmerah and Gandul (Chan and Lee, 1985). Further, the new variety showed good stability over the environments as indicated by regression slope nearly equal to one (for vegetative growth) and 0.66 (for fruit weight) and the least deviations from the regression line (*Figures 4 & 5*). The G x E trial consolidated the earlier confidence bestowed on the Hybrid 1 and it was subsequently released as "Nanas Johor" in 1985.

FURTHER IMPROVEMENT OF RECOMMENDED CLONES

After the long drawn process of evaluating accessions in fruit collections/germplasm, selecting the apparent winners and finally confirming their stability and performance in G x E trials, further work may be necessary in 'cleaning-up' the recommended clones which may still have one or several undesirable characteristics. 'Winners', it must be pointed out here, are time related because consumer preference and industry demands often change with time and the breeding programme must be dynamic enough to meet such changes. With the development of a set of varieties through preliminary selection and G x E testing, these can act as the base for choosing parents in crosses to improve their deficient characters.

"Masmerah" and "Gandul" (Singapore Spanish) are pineapple varieties that are good examples of 'base varieties' which have been around for a long while and which require changes. The Malaysian canning industry, for nearly two decades, had been almost totally dependent on these two varieties because of their adaptability on peat, the major soil type for pineapple cultivation here. Their golden flesh is a definite asset for canning of premium priced fancy cuts but their yield is only 40 – 60% that of 'Cayenne', the standard variety of other pineapple growing countries.

Hybridisation between 'Singapore Spanish' and the large fruited Cayenne and selection in the segregating F1 produced a new variety, the "Nanas Johor". The methodology in hybridisation and progeny selection in the F1 and subsequent field testing has been described by Chan (1986). The new hybrid had better vigour, yield and fruit quality compared with its commercial counter parts.

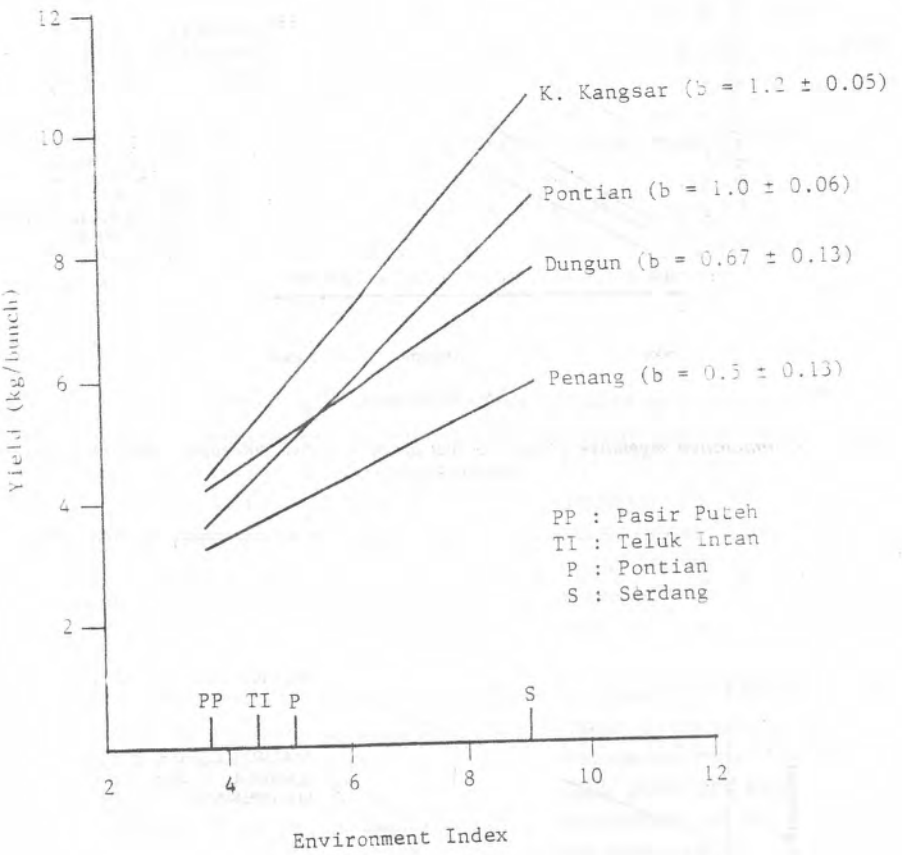

Figure 3. Yield response of four Rastali accessions over four locations

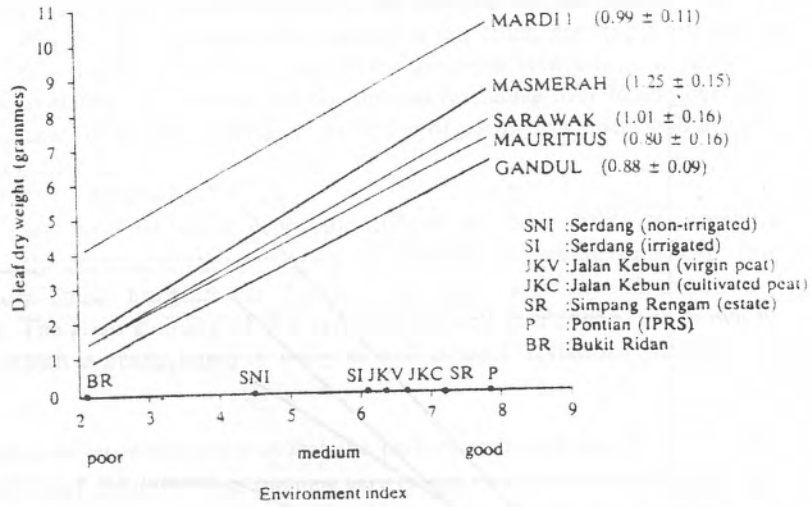

Figure 4. Comparative vegetative growth (D leaf dry wt.) of five pineapple cultivars grown on seven locations

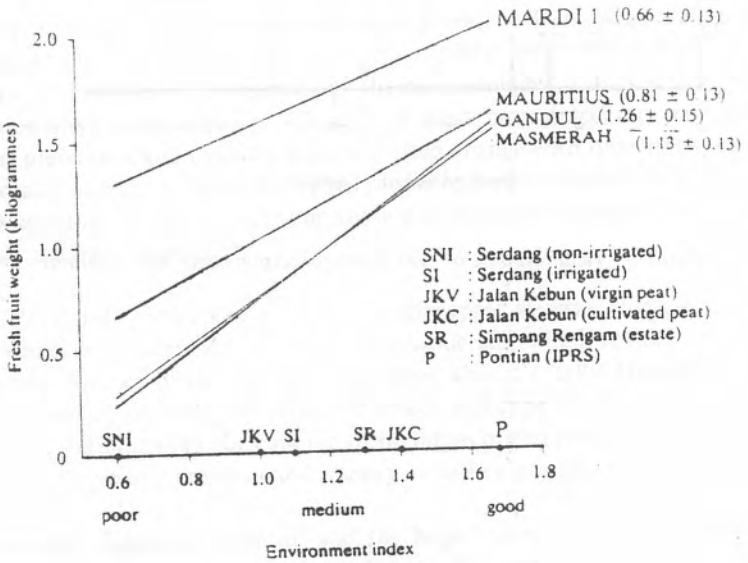

Figure 5. Comparative fruit size of four pineapple cultivars grown on six locations

At the Peninsular Estate (Lee Pineapple), similar progress in improvement of the yield of "Gandul" (its principal variety) was achieved. Selection in the F1 of a cross between "Sarawak" and "Gandul" produced a new variety (Hybrid 36) which the estate is now planting in 40% of its field (Ng, *pers comm.*).

These two hybrids which showed vast improvements in yield, still have several shortcomings. "Nanas Johor" has occassional incidence of marbling fruit while the flesh colour of "Hybrid 36" is not as golden as is required. Two backcross programmes are presently undertaken *i.e.*, "Nanas Johor" x "Spanish" (resistant to marbling) and "Hybrid 36" x "Gandul" (rich golden flesh) to further improve the quality of these new hybrids.

INCREASING PRODUCTIVITY OF CLONAL POPULATIONS

The discussions have, hitherto, been focussed on selection and evaluation of the selected genotype *per se*. Let us now deviate from this and consider the performance of the clonal population on the whole and the ways in which productivity of the population can be increased.

Selection for dwarfing rootstocks

Perennial fruit types such as durian, rambutan, mango and cempedak are conventionally grafted onto foreign rootstocks which are usually of non descript origin. There is just as much need, therefore, to pay attention to selection of rootstocks as of the scion. One of the major roles of rootstocks in increasing productivity of clonal population is imparting dwarfness to the scion. The present density for the majority of perennial woody fruit species ranges from 70 to 90 trees per hectare. Dwarfing rootstocks induce smaller plant structures and considerably larger numbers can be planted in an unit area. With the attendant advantages of precocity and convenience in fruit harvest, productivity per unit area per unit time will be invariably increased.

For the local fruit species, little has been achieved in this area of work, although there is some evidence that *Annona atemoya* (Queensland custards) shows slower growth when grafted on *Annona squamosa* (local custards) compared with that on *Annona cherimola*. On the contrary, a number of dwarfing rootstocks have been identified for many pome and stone fruits in temperate countries. The East Malling dwarfing apple rootstocks, for example, and the successful implementation of meadow orchards should be emulated for intensive close cropping of local fruits in improving the productivity of the clonal population as a whole.

Clonal composition

Determining the clonal composition or mixture is important for those fruit species whose clones are mostly self-incompatible and require pollination from other compatible clones for good productivity. Durian is a good example in which breeding should not be confined to the selection of a single clone because recommendation of it *per se* as an orchard monocrop will be disastrous as most local accessions are self-incompatible and therefore, will not set fruit well in monoclonal situations. Clonal mixtures, in which each clone is selected based on good performance, stability as well as cross-compatibility with each other, should be recommended. Further, xenic effects have been observed and fruit quality can be affected to a considerable degree due to different pollinator source. In this respect, suitable complementary pollinator clones based on compatibility and favourable xenic effects on the selected genotype must be identified in the breeding programme.

"D24" has proven, over nearly half a decade since it was first registered, that it is still one of the more reliable, consistent and good quality clone. It is also however, self-incompatible. Compatibility studies using D10 as the pollinator clone indicated that fruit set of D24 is considerably

improved (96% set) compared with selfed or unpollinated treatments which failed to set any fruits (Shaari, Zainal Abidin and Mohd. Shamsudin, 1985). Fruit development was also better, yielding larger and more rounded fruits with fewer empty locules. Seed number was considerably higher although there was no difference in percent aril between D10 pollinated and unpollinated fruits.

Recently, crosses of D24 with D99 indicated that the latter, which is self-compatible, is another potential pollinator for D24. Fruit set obtained was in the region of 60% (Shaari, pers. comm.) and favourable xenic effects were exhibited because pulp colour appeared richer with a smaller number of seeds compared with fruits pollinated by D10. Further, the number of shrivelled seeds (an important quality consideration) was considerably higher.

The clonal composition presently recommended is 60% D24, 30% D99 and 10% D10 or D98.

CONCLUSION

Breeding and selection of clonally propagated fruit species is fairly uncomplicated because high quality genotypes, once identified and selected, can be fixed genotypically and reproduced faithfully from generation to generation using vegetative propagation. It is, however, a long term process particularly for the woody perennials because following the preliminary selection, an elaborate genotype x environment trial is carried out to test the relative performance and stability of the selected genotype in the company of standard cultivars over several locations and seasons.

Those that pass through this rigorous test are 'winners' only within a certain time frame because of the dynamic consumer preference and industry demands. Further, certain weaknesses, not apparent at the time of release, will become increasingly important and have to be redressed to restore its worth as a commercial variety. In this respect, varieties selected in the earlier phase can act as base materials for breeding programmes such as hybridisation and backcrossing to ameliorate the deficient characters.

Finally, to further enhance the performance of the clonal population as a whole, there is a need to select for dwarfing rootstocks for increasing density, precocity and productivity of the clonal population over time and space. In the case of the self-incompatible durians, selection of other compatible pollinator clones for planting as mixtures to increase fruit set and productivity in the population is an important consideration.

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JOINT DISCUSSION
SESSION D

Chairman

We thank Encik Jamadon for an interesting delivery about cocoa which is quite an important crop to us here in Malaysia. Obviously some of the points we already made about woody trees and separate root stocks and so on would apply here. Are there any points anybody wants to make specifically about cocoa? As I understood it, the ortets selected performed well above the average for the family whereas the ramets were below the performance of the ortets in fact just above the average for the family. Is that correct?

Soh

Leading from that question, have you computed the ortet ramet correlation?

Jamadon

No, we have not done such an analysis. What we have presented just now are based on the data recorded for separate clonal trials and the ortets. No correlation has been made between the two.

Chairman

What is your guess of the level of yield increase we can expect between seedling and clonal cocoa plantings on the first plot of clones if we should plant on a large scale.

Jamadon

We have recorded a yield of about, as mentioned, 2 tonnes per hectare per year based on all of our released clones and the progenies can reach about 1 tonne per hectare per year. These are from our former progeny trials we have in our stations.

Chairman

Dr Soh, does that answer your question?

Soh

The original cross or seedling materials are planted at the same time as the clones, in the same trial?

Tang

The size of the plot from which you measure your 2 tonnes per hectare?

Jamadon

This is from extrapolation values but it is not really from a big clonal trial. We extrapolated to a hectare where we expect about 1,200 stand under mono culture system.

Chairman

How big was the plot for you to get .....

Jamadon

Normally we carried out about 60 to 80 plants at each trial. Of course replicated three times which means about 20 plants per replicate. We do this of course at multi-locations to observe their adaptability.

Chairman

Has anyone any points they would like to make on the subject of rubber or fruits? One of the things that struck me is that there are some lessons and some variabilites. One of the latter is that these are not actually in the fullest sense of the term clones because they are all grafted into seedling root stocks which does lend a degree of variability to the plant which may have some significance. Any comments on that? If you are going to grow your rubber, for example, although they are all the same clone they are quite different in size.

Mohd Noor

I would like to comment on the seedling root stock and scion interaction. Our study has shown that there is some considerable variation due to the two interactions between the stock and the scion. And this, I think, probably in the future will with tissue culture become a one part tree.

Chairman

Do you not think though that some variability is perhaps even helpful?

Mohd Noor

When we select the clone, as far as rubber is concerned, we try to reduce variation within the clone as far as possible. That's why now our strategy is to select for vigorous root stocks and we have identified a few monoclonal seedling root stocks, for example, GT 1 which could thrive well in the marginal areas, and for dry areas in the north, RRIM 603, PB 5/51. Our studies have somewhat indicated that these three clones could give a positive interaction to the scion clones, selected scion clones.

Chan

In the area of root stock-scion interaction for tropical fruit species, I think very little work has been done, except of the little that we know about, the custard apples. I will share the sentiment that the variation which exists for rootstocks from different origin will be a good thing because then we will be able to identify or select the rootstocks that will give the best performance to the scion. But so far we have not made any headway in this respect.

Ollagnier

Is it possible to ask some more question on rubber and tissue culture and know where RRIM is for this technique.

Mohd Noor

Probably I could direct this question to Dr Ghouse. He could comment on the status report on our tissue culture work at the RRIM.

Ghouse

If you would like to know more about rubber, in fact the tissue culture of rubber has just been reviewed last year when we had the symposium. Anyway, as far as we are concerned, we have plantlets in the soil and we are in the process of mass multiplication of the rubber clones. But as far as RRIM is concerned, we are trying our best to meet the demands of the rubber industry and we are slowly progressing towards that goal.

Chairman

Could we ask what are clones being planted?

Ghouse

For your information, in Malaysia we have three different clones that were successful and these were RRIM 600, GT 1 and Tjir 1.

Chiu

I have two questions for Mr Chan. Question 1 is that you have shown that D 99 and D 10 are compatible with D 24, giving real good fruit set and pulp. Have you any experience with D 96 and D 2 or D 123 as compatible pollination donors for D 24?

The second question is on the two fruits shown. Those two fruits have real good attractive pulps. Were they fruits from D 24 trees that were pollinated with pollen of D 99 and D 10?

Chan

To answer the second question first, yes. They were pollinated with D 99 and D 10 clones respectively. As I have said before, there is xenic effect and the favourable xenic effect is found when the D 99 was used as a pollen.

With regard to the first question, we have not used a complete set of local clones to be used as a pollinator for D 24. But we have identified also two more, which is D 53 and D 98, but not with the D 96 or the D 2.

Chiu

You mean you have not tried those two?

Chan

No, we have not tried them.

Chiu

I asked about them because they were also very popular clones planted.

Soh

I have two questions for Dr Mohd Noor. Firstly, in rubber you did very extensive clonal testings before you raise varieties and after thirty years of work and over thousands of acres before you end up with a few good clones. Do you think this is a consequence that you are operating on a very narrow genetic base?

Secondly, I would like to know the rationale of going into mass selection. Normally we understand that when you want to proceed with mass selection, we are dealing with a population which is still rather genetically heterogeneous such as a landrace. And when we are selecting, we are probably selecting for highly heritable traits.

Mohd Noor

To answer your first question on the relationship between the long testing cycle and the narrow genetic base, I agree with you that there is some aspects, some relationship. But with rubber breeding we always suspect that, we are always dealing with a narrow genetic base. On the other hand the long testing cycle is needed because we are dealing with a perennial crop. We have to go to that sort of long testing stages for rubber breeders to be more assured when we recommend that particular clone to the industry. At least the industry will have more confidence in the RRIM's planting recommendations. But we realise this. That's why we have this programme on promotional, plot clone trial to short-circuit this long testing cycle from 30 years to 20 years. They have shown some results. In fact some of our recent 900 series come from this programme; promotional plots clone trials. But these trials go in parallel with the conventional breeding which takes thirty years.

As to your second question on the mass selection, our analysis on the variable seedling population, GG 2 to GG 8 now seedling population has indicated that there are a lot of variability present. So I think there is some basis in that sense to go for at least a complementary method to help in the selecting of good clones, rather than going through our conventional approach of using hand pollinated seeds.

Rajanaidu

Could you please indicate roughly what is the level of coefficient variation for latex yield within the RRIM 600?

Mohd Noor

It is in the region of 30 to 40%. That indicates the variability of the rootstock and also the environment of where you plant this RRIM 600. Because in some areas, RRIM 600 will not thrive well, especially in the north where this clone is very susceptible to phytophthora and pink disease.

SESSION E: CLONAL TESTING TECHNIQUES AND PERFORMANCE

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CLONAL TESTING TECHNIQUES AND PERFORMANCE

N. Rajanaidu*

INTRODUCTION

Clonal testing in the field is the logical sequence after the production of plantlets in the laboratory. The method of testing will vary with the objective of the trial and we have enumerated here the various objectives and the method of testing the clones.

A summary of the published data (Corley 1983; Guillermo, 1985; Anon, 1983) on performance of clones are given here; concentrating mainly on yield parameters. It was not possible to get the latest yield data of the trials mentioned in this paper. Hence, the results and conclusion outlined in this paper are only preliminary.

The main research organisations involved in the clonal testing were not able to present this paper and we have prepared this write-up largely to stimulate discussion on this subject.

OBJECTIVES OF CLONAL TESTING

(1) **Identification of superior clones**

The main objective of testing is to identify the superior clones. As the clones of different diverse origins emerge from the tissue culture laboratory, they will be tested in the field as soon as possible to assess their merits.

(2) **Experimental designs**

The initial clones should be also tested in different experimental designs in order to simplify the future clonal testing (Hardon *et.al;* 1982). For example, clones are tested in fan design, randomised complete block design (RCBD), honeycomb, and completely randomised design (CRD) at Bakasawit, CRD and RCBD at PORIM Research Station at Ulu Paka and Kluang. The fan and honeycomb designs are tailored to examine the suitability of planting densities for individual clones. Information is also needed on replications both in terms of blocks and palms per block.

(3) **Improve selection method**

Early clonal testing will also provide information which will in turn assist in the improvement of selection methods and the value of different selection criteria. Clones selected by different methods will be compared; for example, the performance at high density of one clone from an ortet selected for high harvest index (HI) and others selected on ortets response to severe pruning or low nutrient level (Hardon *et.al* 1982).

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(4) **Clone x environmental interaction**

It is likely that these interactions will occur; that is, certain clones may exhibit wide adaptability while others specific adaptability. Hence, it is necessary to test the clones in different environments. The ability to multiply specific genotypes manifold permits selection for specific traits and particular environments.

(5) **Clone x fertiliser interaction**

Evidence from other crops suggests that there may be clone x fertiliser interaction. It is therefore worthwhile to test clones at different nutrient levels.

(6) **Clone x density interaction**

With the clones, it is possible to obtain more precise information on clone x density interaction.

The competition and its effects on oil palm performance are poorly understood. The period of evaluation will ideally span from the time of first bearing to the period of stabilised yield.

METHOD OF TESTING

Stepwise testing of clones will be most efficient. The number of plantlets per clone and possibly number of test sites should be increased as soon as performance warrants more intensive testing. Clones not attaining minimum standards should be dropped off and their recording in initial trials also be terminated. To ensure a wide range of available clones, and for diverse environments, selection criteria in the initial tests should not be over rigid. (See *Figure 1.*)

For *small scale clonal trials* about 30 – 60 plantlets per clone is sufficient for quick screening. With 1 – 2 years yield data, it may be possible weed out extremely poor clones and gradually increase number of plantlets of promising clones for clone x environmental interaction, clone x density, clone x fertiliser interaction *etc.* studies.

PERFORMANCE OF CLONES

Bakasawit has laid down about ten trials testing clones derived from seedlings. The first clonal trial of selected ortets was laid down in 1981 at Pamol Kluang.

Table 1 gives the performance clones planted in clonal trial no. *3* at Pamol Kluang. In this trial five clones (924,926, 949 and 975 and 997) of unselected ortets are compared with mixed commercial DxP seedlings. These were planted between July 1978 – December 1979 at 138 palms per hectare. The first three year yield data show that clone 997 gives FFB yield of 13.27 t/ha/yr and oil yield of 3.20 t/ha/yr as compared to 12.84 t/ha/yr FFB and 2.56 t/ha/yr oil for seedling control.

Table 2 provides the first two year yield data of Clonal Trial 8; planted in 1980 at Pamol Kluang. In this trial, 13 clones of unselected ortets were compared, clone 914 gives the best oil yield of 4.1 t/ha/yr.

Clones from unselected ortets (926, 924 and 975) are compared with a commercial DxP seedling control in a 4 x 4 Latin Square with ten palm plots in the trial 79/1 at Lobe, Cameroon. (*Table 3*).

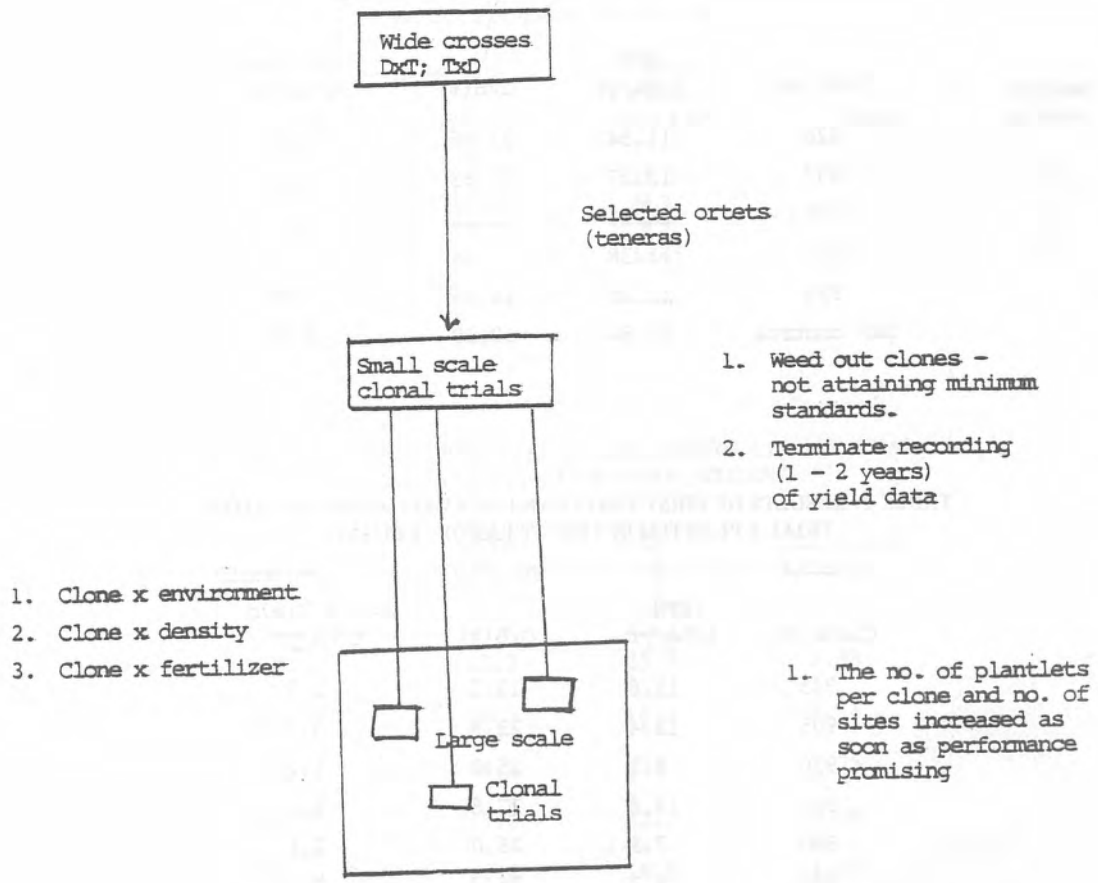

Figure 1. A method of testing oil palm clones.

TABLE 1: RESULTS OF FIRST 3 YEARS OF EVALUATION IN CLONE TRIAL NO.3. PLANTED IN 1979 AT PAMOL, KLUANG.

Clone no	FFB t/ha/yr	O/B(%)	Oil Yield t/ha/yr
926	11.54	23.36	2.64
997	13.27	23.63	3.20
975	12.16	21.21	2.77
947	11.38	21.36	2.58
924	11.35	15.55	1.86
DxP control	12.84	19.39	2.56

TABLE 2: RESULTS OF FIRST TWO YEARS OF EVALUATION OF CLONE TRIAL 8 PLANTED IN 1980 AT PAMOL, KLUANG.

Clone no	FFB t/ha/yr	O/B(%)	Oil Yield t/ha/yr
945	11.6	10.2	1.2
905	12.4	23.9	3.0
910	8.1	15.0	1.2
914	14.8	27.8	4.1
960	7.9	26.0	2.1
949	9.1	26.2	2.4
937	8.7	26.5	2.3
933	12.2	24.2	2.9
966	11.7	25.5	3.0
926	8.7	26.9	2.3
950	6.3	20.1	1.3
995	11.1	22.5	2.5
997 (Control)	10.8	28.5	3.1

TABLE 3. RESULTS OF TEST 2 YEARS OF EVALUATION OF CLONES PLANTED AT LOBE, CAMEROON IN 1979.

Clone no	FFB (kg/palm) 1982	1983	Mean FFB (1982 & 83)	O/B(%)	Oil Yield kg/palm
926	40.4	29.9	35.15	20.8	7.31
924	34.0	34.4	34.2	16.9	5.78
975	0.6	16.8	8.7	22.1	1.92
Seedling Control	32.8	42.1	37.45	18.2	6.82

TABLE 4: RESULTS OF FIRST YEAR EVALUATION OF CLONAL TRIAL NO. 11 PLANTED IN 1981 AT PAMOL, KLUANG.

Clone no	FFB t/ha/yr	O/B %	Oil Yield t/ha/yr
115E	12.9	23.7	2.99
31A	14.3	16.5	2.14
54A	14.1	17.7	2.35
90A	7.6	12.1	0.96
997	9.0	16.6	1.45
Elite DxP cross (Control)	15.4	18.5	2.46

Yield recording and bunch analysis commenced in October 1982 and FFB yield results for 1982 & 1983 are:–

Clone 926 produced 7.2% more oil as compared to seedling control.

Clonal Trial no 11 (*Table 4*) was planted at Pamol Kluang in 1981. The results of this trial corresponding to first year of harvesting (taken 31 – 43 months after field planting) are shown in *Table 3.* An elite DxP cross was used as a control. This trial is of great interest because the clones are produced from selected ortets (31A, 54A, 90A and 115E). The clone 31A was selected in a progeny which yielded well under severe pruning; 54A was selected for reasonable yield with low nitrogen in a fertiliser trial; 90A was selected for high yield together with high bunch index and 115E was selected for high oil yield alone. The comparison of these clones will provide information on the selection procedure. This trial was planted in two planting densities (138 and 173/ha).

The first year data shown that clone 115E is the highest oil yielder (2.99 t/ha/yr) as compared to 2.46 t/ha/yr of seedlings; *i.e.* a difference of 21.5%. It is too early to draw firm conclusions with one year yield data.

Jones (1984) reported distinct clonal differences for fatty acid composition. However, the level of variation in these clones is comparable to the variation in Nigerian palms (Rajanaidu *et.al.* 1982).

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GENERAL PRINCIPLES FOR CLONAL TESTING AT I.R.H.O.

L. Baudouin*

Clonal tests are an essential step in the improvement of oil palm by "in-vitro" culture.

The first type of clonal trial used at IRHO is aimed at assessing the value of clones before releasing them as commercial planting material. Its design is quite similar to normal seedling trials, with small plots in randomised blocks. In order to measure the progress achieved by cloning, it is necessary to include in those trial seed propagated material of the same origin.

Another kind of trial is conducted in semi-commercial fields, where the different clones are planted in large homogeneous blocks. This will enable us to check the possible problems posed by between palm competition, and by pollination efficiency which can not be studied with small plots. Other special trials have also been planted at La Me: e.g., one with the objective to compare between two clones planted either in homogeneous plots or in alternating lines, in order to determine the effects of competition.

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JOINT DISCUSSION

SESSION E

Chairman:

The papers are open for questions and elaboration if any.

Ho

Dr Rajanaidu, I think in your slide, you did say early selection at two years.

Rajanaidu

Is it two years for the selected or unselected ortets?

Ho

I saw the two years there, are you talking about early selection in this case?

Rajanaidu

Yes. In fact there is one trial with three year yield data, in the first transparency, the last transparency I showed only one-year yield data. The one before had a two-year yield data. So I have a three-year yield data, a two-year yield data and a one-year yield data.

Ho

Are you proposing that you should practise early selection before cloning.

Rajanaidu

I am just presenting data, whatever available, to show the performance of the clones which have been planted so far. I am not proposing anything. It is just to give a rough indication of the performance of clones against the DxP control.

Ho

I could be wrong but I thought I saw in your flow chart a mention of two years.

Rajanaidu

It varies from trial to trial.

Chairman

Could IRHO please clarify the actual number of ortets selected and the total clones that are available at La Me.

Bauduqin

The ortets taken at La Me were 170.

Chairman

But how many are actually producing plantlets?

Bauduoin

The number producing embryoids is 87.

Ollagnier

If the embryoid cultures correspond to the terminology of PORIM's poly-embryogenic cultures of Dr Paranjothy, we have today about 28 clones with potentiality indefinite, we hope.

Chairman

Twenty-eight out of 170 selections seems to be . . .

Ollagnier

But this is overall view and naturally the percentage is higher from the ortets put into culture, because the figures include also the trees that have been started in 1985.

Chairman

I have another question for IRHO, which is, they are using these to make trials as I understood it in South America and Africa. I wonder if there is any other continent that has been missed out in the list.

Ollagnier

No.

Chairman

Is there any interesting continent added on to that?

Ollagnier

There are some smaller consignments which have been sent to agencies like United Plantations. They have received something recently.

Chairman

Some other agencies received suggestions that they might like to take some and when they agreed to it they never heard anything more about it.

Ollagnier

I do not know.

We are quite disposed to sending (clonal) materials.

Rajanaidu

Mr Chairman, PORIM itself is supposed to get the IRHO clones in September this year for evaluation in the field. So you can add one more continent.

Chairman

So that's fine. They all can be compared together. One of the things that occurred to me from Dr. Rajanaidu's delivery was that we have evidently unselected ramets, ramet clones which are out producing controlled DxP by 21% and I agree that's only in the first year which is not necessarily typical.

Rajanaidu

That gives three years' evaluation. The first trial I have shown gave a three-year yield data.

Chairman

And that is the figure 21.5% over the DxP control? So that would leave the impression that the 30% isn't all that way out.

Rajanaidu

At the same time I have also given one more trial planted in Cameroun, clones derived from unselected ortets, where the best clone gives only about 7% more than the seedling control. So there is a lot of variation, in the performance as will be expected. It may vary from trial to trial and the type of clones.

Soh

Without sounding as though I am trying to defend my position, just to note that the 20% figure that you got there for ortet clones, I mean the superiority of ortet clone 115 E over seedling control, you can see the seedling control has an oil to bunch of only 19% which is very low.

Chairman

Yes, you obviously got to plant a pretty lousy control to get these figures.

Soh

Secondly, as far as I understand just from private conversations, clone 115 E has the habit of having very marked year to year fluctuations in yield pattern. This is only one year yield.

I would like to take the opportunity to ask the next question. These clones have also been planted elsewhere too. Do they show any so-called GxE interaction? Are the rankings about the same? I am throwing the question to those who are involved in the testing of these clones.

Chairman

Could we get an answer to that, even a generalised one?

Lee

First of all, I would like to comment on what Dr. Ho had said regarding the early yield data. Based on our experience, looking at the initial data that we have, it appears that a longer period of yield recording is necessary in order to confirm whether a clone is good or not. As regards to whether there is any clone x location interaction, our early yield data did indicate that there are some clonal x location interaction. We have got materials that do well on inland soils as well as materials doing very well on coastal soils.

Ollagnier

I refer again to the communication from the plant breeder from HRU. It's only a personal reflection. When I consider for instance for the case of sites I know quite well in Ecuador in which has been established one plantation of 4,000 hectares and another of 5,000 hectares. One plantation is planted with Deli x La Me material, while in the other is material from Dami. In these plantations, we often have to face the problem of (inadequate) pollination. During the first there years of harvest, we really do not have any male flower and it is extremely difficult to install the famous *Elaeidobius kamerunicus* (weevil) which has been imported there. With trees which are producing more than 30 bunches a year, I wonder how tissue culture could further increase the number of bunches. You cannot have more bunches than leaves produced every year. Possibly, I wonder, if your computations would give the same results if you were applying them to palms of more mature age, for instance between 15 and 20 years. Don't you think you would have greater heritability of the (bunch) production?

In the beginning the palms would have such a complete female phase that no yield is possible which can occur if selection of clones is too much biased towards high bunch number. In this situation perhaps it would be better to plant first with clones having large bunches and then later with clones having many bunches.

Soh

I think that is a very fair question. As in any perennial crop, the heritabilities will always change in time but whether they will change significantly or not we do not know. The point I was trying to bring across actually was we are dealing with very narrow genetic base when we are talking about Deli dura crossed by AVROS pisifera. So we still do not think that heritability will be very much improved over a longer period between palms.

Rajanaidu

Mr Chairman, in response to Mr. Ollagnier comment an the situation in Ecuador where female inflorescence predominate in the early yielding stages, I would like to say that we have two distinct types of planting materials. We have high bunch number and low bunch weight type or you can select for high bunch weight and low bunch number type. So under the circumstances as in the case of Ecuador, it may be worthwhile to plant some of the Socfin type of materials which has a high bunch weight so that you will still have enough male flowers for pollination.

Ollagnier

Yes, we have naturally observed some differences within the Deli x La Me between some hybrids which are more or less, have some differences in sex ratios. I think it is not possible to expect the figure of 30% increase in production of the younger aged palms due to the impossibility for the bunches to be more numerous where there are interesting ecological conditions. In West Africa where water deficits sometimes are very severe the problem can be different.

Chairman

This is a fair point which we may take into account in making our selection.

Tan

I get the impression that everything is going very smoothly for the tissue culture materials and it gives me really a feeling that I have done something very wrong and I hope that people will help me to right the wrong that I have done in the few clones that I have in United Plantations. Firstly, I understood that the clones are much more uniform than the progenies. We have done measurements on frond length and found that actually our two progenies are more uniform when compared with the four clones. Maybe we do not know how to handle the clones. The other thing which struck me was I thought that if we are producing from a single plant, then all the ramets should also follow the same spiral as the parent or the ortet. From what we can assess, the ramets performed like the seedlings, they have left and right handed palms in almost equal proportions

These clonal palms, have just come into bearing for the last five months now. We did about six months of ablation before we brought them into production, and we found that all the four clones, have produced mantled fruits. For those who are not familiar, I have some slides actually to show what a mantled fruit looks like. I even brought some samples. In one clone, 95% of the palms show this character of mantled fruits. The best is in one clone which has 58% of the palms showing mantled fruits. Whereas in both (seedling) progenies we do not have any of the mantled fruits. So I think we have not done anything wrong to create the mantled fruits in the field.

So I am now very confused and I hope that the members with much greater experience in dealing with clones will help me avoid this type of problems.

Chairman

Has anyone else experienced mantled fruits with clones? Would it be unreasonable to ask the source of these clones? Even if you do not want to give a particular name, whether they are from the private sector or the public sector?

Baudouin

In IRHO we have experienced one single clone that had and still has mantled fruits. But this clone was selected from an unknown source as a study material and it was in the early history of cloning at IRHO and maybe, we think, the tissue culture manipulations may be the cause of this defect. But on other clones we have no mantled fruits.

Chairman

Shall we have a break and take a look at the slides on the mantled fruits.

Baudouin

What is the origin of these clones?

Tan

I have obtained them from an outside source, so I do not know.

Chairman

You mean outside Malaysia?

Tan

No, outside the United Plantations.

This is what the bunch looks like.

Probably I'd like to explain that, invariably if all the bunches show these mantled fruits, we have yet to get one bunch ripen normally. They could dry up before they ripened. In all these cases where you have multiple fleshy materials surrounding the fruit, they are parthenocarpic, whereas if you have only one or two of these fleshy portions then the fruits can be normal.

Chairman

Is there anyone else who has experienced this problem, IRHO said they have it with one clone which it would seem that you would be extremely unlucky to get it in four out of four.

Rajanaidu

Since there is no response from the organisers as well as from the . . The same clones are also planted elsewhere but at UP, I understand, it was planted on peat soil.

Tan

No, it is not on peat soil. It's on Selangor series soil.

Rajanaidu

Sorry. But in the other places they have not mentioned similar characteristics, just to clarify the situation.

Chairman

These are the same clones you mean. Well, obviously this is a matter that has to be borne in mind also and you have to continue to observe. Maybe they will grow out it if you are lucky. You have not been using the wrong kind of herbicide or anything because you said that the seedling population has been normal anyway?

Tan

What I would like to ask is, if there could be any explanation to it.

Chairman

Nobody here appears to have one. I think if you refer back to the source of the clones and discuss it with them.

Rajanaidu

One aspect of the mantled character is that it is a genetically dominant character. Because of that it worries me.

Chairman

Well, you will have to wait and see. Have you got some more clones coming along so that you can see whether they produce the same thing or not? Find out whether it is the atmosphere or . . . .

Ho

I would like to go back to the tables that you mentioned in Rajanaidu's paper. It is very significant that the point that Dr Soh mentioned that. I think, we should emphasise more on the more highly heritable components i.e. mesocarp to fruits because in all the tables on that, the improvement have come largely from the better oil to bunch rather than from the fruit (bunch) weight themselves.

Yong

At Bakasawit we have a whole range of clones, some are from selected and some are from unselected ortets. We do have one clone which shows mantled fruits. In fact, throughout the whole population of this clone we got mantled fruits. And this clone is not derived from selected ortets. It only shows genetic uniformity in one sense. We also have clones which are performing very well but it is too early now to comment on the performance of these clones. I would refrain from elaborating more in the yields of these clones. I think it is very dangerous. Because those results which Rajanaidu showed just now was for the first year of harvest. The picture has changed entirely now.

GENERAL DISCUSSION

Chairman

We now have a session called General Discussion. I am not sure how necessary this is because I think most topics should have been thrashed out fairly thoroughly but has anyone any general observations they would like to make? Any general points they would like to bring up further to what has already been said?

Chiu

I just thought about this because of UP's experiences and problems with the clonal planting and with the figures soon approaching release for commercial planting of clonal oil palms. Are there any standards, or is SIRIM setting any standards for safeguarding the planters' interests as far as their confidence in planting clonal materials and if so, what kind of standards would they set or what would the people here recommend?

Chairman

Regarding the question of standards, is there anyone here qualified to make a statement on that point? I haven't heard of any being set for clonal materials.

Rajanaidu

In fact, it's a matter of coincidence. Only two weeks ago, all the breeders got together to try to review the standards as set by SIRIM for the D x P planting material. So far we do not have any plans of review. In fact the request to review came from the members of the industry itself to set the standards. As it is, the amount of planting materials produced by the tissue culture technique is limited, it may not have much impact on the industry yet. So once a significant amount is produced as commercial planting material, then there is a need for standards in clonal planting material.

Chairman

At the moment, in fact, presumably one can sell anything without any guarantee of what it's going to do. That is as much as anyone here can tell you. There aren't any standards at the moment but no doubt as soon as clonal palms become more established and one can relate them to a normal palm, standards can be drawn up and no doubt will be.

Neoh

Mr Chairman, I wonder if we can spend some time talking about the quality of the oil. I am saying this because there is no point being the most efficient guy in the world if all the markets are closed to you as, for instance, now the price of palm oil is very close to the production cost. I am wondering whether we should not target ourselves to all the niches available. For instance, talking about saturation of oil, the polyunsaturated, monounsaturated and the cholestrol level. As you know all these have been very controversial subjects so far and in our breeding programme, should this not be therefore a very important factor of consideration? For instance, as you know, the olive oil has

been called the Rolls Royce of the vegetable oil and because of its mono-unsaturated nature and it has some ingredients that can actually dissolve the cholestrol or lower the cholestrol level of the human body. Would we not therefore be able to, with the help of tissue culture, produce palm oil, if you like, that can target itself to all kinds of demands and all kinds of niches.

Chairman

Are there any comments on that? I believe it is one of the objectives that has been deeply thought about. I am not sure. Dr Rajanaidu, you have any points on that one? You mentioned it in your paper.

Rajanaidu

Mr Chairman, I think Mr Arasu wrote a thesis on that. I think that he will be better disposed to answer.

Arasu

Mr Chairman, it is not true that I wrote a thesis on that but nevertheless, I did look into the, at least the literature situation on this whole controversial subject and really, there appears to be very little to go on to justify the high value being placed on moving palm oil fatty acid composition away from its present composition. Nevertheless, the whole thing should be looked at, I think, by a group of knowledgeable individuals, not just plant breeders or oil technologists, but a combination, a team, of all kinds of breeders and marketing people, to look at what the future holds and not what the situation today is. The situation today is certainly confounded by the strength of various lobbies and varied medical opinions on the question, for instance, and of course this is tied up with the marketing situation too. There is a premium for margarine, for instance, with high polyunsaturated oils. But this comes from the fact that people are afraid of having, or taking in too much saturated fatty acids at the moment. And yet, the medical evidence for this is at best tenerous. All I can say is that one should look at the whole situation with an open mind. But Rajanaidu said earlier on that a task force has looked into this and the future is in fact for liquid oils. On the basis of published information, I am not convinced, but the task force has gone into details so I cannot question it unless I look at the task force's report. But the future trend in production is for larger and larger volumes of liquid oil coming onto the market and rather less and less of non-liquid oils. So I am a bit surprised that the future is in fact in favour of going more liquid.

Chairman

That seems to echo the views in general. Any other general points on that particular topic of composition? I think it is established that if a hybrid palm could be cloned, there would be a possibility of producing more liquid oil. A lot of people think if that is done, it is only going to be an alternative product and not a replacement for palm oil as it currently is.

Mohd. Noor

I would like to bring up another problem besides the oil quality, that is on the widening of the genetic base. I would like to refer my question specifically to Dr Rajanaidu.

For the past decade, PORIM has collected a tremendous amount of germplasm material. I wonder whether PORIM should go for further collection or should sit down and consolidate research on this. In this case, they have to know what sort of existing variability is present in the, already collected germplasm material. Mr Chairman, why I ask this question is that we are also in a dilemma in the RRIM, as to whether to go for a second collection or not.

Rajanaidu

As far as PORIM is concerned, our main objective is to try to make a representative sample of the cross section of the belt of wild palms from Sierra Leone up to Angola. We have covered most of the important areas. The main area still left is Angola. Maybe in the north we may collect in Ghana or so. I think we have for the present a large amount of germplasm material. For the past two years, we are analysing and summarising the value of these materials. We accumulated a lot of yield, bunch analysis data and also on the variability of fatty acids. That's how we are able to release or able to identify some of the interesting Nigerian palms which should be utilised immediately by the industry palms which are high-yielding, short and with high extraction rate. As far as the germplasm collection for oil palm is concerned, we have nearly completed the collection of oil palm germplasm.

Chairman

Does the answer satisfy you Dr Mohd. Noor? Any other general observations or comments?

Soh

I'd like to respond to Dr Lee's earlier comment on the preliminary indications of clone x location interactions which have implications in terms of the size of testing that we have to do. What I would like to ask is that whether the clones came from one genetic source or a number of genetic sources.

Lee

Actually the clones are derived from materials selected from both coastal and inland environment. Even with the materials from coastal environment itself it does show some clone by location interaction. In one case, we have got one particular clone which does not do well in most of the locations tested except on peat. As I said earlier, these are very early indications and things might change after one or two years. So we should not really jump to conclusions at the moment.

As I said just now, all these are very preliminary data based on the first two years and we may not know what will happen subsequently. So that is why I have indicated earlier that a longer period of yield recording may be necessary in clones.

Chairman

I think the question is a little bit more specific than that. You may or may not be able to answer it but the question was, "were the various materials that showed different rankings in different environments from a narrow genetic source or a wide, various or different sources?"

Lee

Well, the two clones that we have were from AVROS base. The others are from Pamol. I don't really know the base of the materials from Pamol, so I can't answer that.

Ho

This question of oil to bunch again, looking at the tables of Rajanaidu's it seems to be quite variable. Looking at your say, 997 which is the control in the three areas, in Table 1, Table 2 and Table 3. I agree that in Table 1, Table 2, they rank highest, but in Table 3, its quite low down in the oil to bunch and so it's not so stable. Can we have some clarification on that point?

Also, the clone-environment interaction seems to be very marked when we compare let's say Table 1 with the results in Cameroon.

Rajanaidu

Mr Chairman, from what I understand they used a different control, D x P controls, in different sites. I don't think they have used the same D x P control.

Ho

We are just talking about absolute values, the ranking.

Rajanaidu

As rightly pointed out, most of the differences are due to the oil to bunch which decides their ranking. In fact I didn't have much background information on the D x P materials to make any comments on this. We have presented these data just to give an indication of the current performance of the materials from the published data because nobody else wants to come forward to present any information on the clonal performance. For these trials laid down by others, I think they should respond. I have presented these data just to provoke discussion and response from the interested parties.

Ho

If I can add on to that, looking at the results, obviously what Dr Soh said is very important, in that we need to emphasise the oil to bunch. The fact that you selected your 115E and that came up tops based on oil selection indicates that we are in the right direction but at the same time, looking at the population that we are talking about, and the table that Dr Soh showed this morning, it is rather worrying that the chances of picking up winners are really very, very small, meaning that the sooner we get the wide crosses going, identify the parent materials and release them to the commercial organisations for their breeding efforts the better.

Chairman

One point I would make here is perhaps is that oil to bunch does vary, very much in the first year. It is subject to quite a lot of variation, particularly earlier on and even later on you get quite a bit of variation simply because bunch size varies so much in this configuration. The other point I would

make is perhaps picking winners is more difficult before the race than it is afterwards. And we have not had the race yet to compare all this in clones so it can be quite dificult to decide but I think once we have done the field tests and compare them, then it is going to be quite easy to decide.

Rajanaidu

One of the problems of clones versus D x P progenies is, by the time we get the information on the clones, we will have D x P material one generation ahead of clones. In fact, we have to compare the first generation of clones with the next generation of D x P materials. Only then we can see or, we can make a valid comment whether there is a real improvement or not because both will come into the market at the same time.

Chairman

That is quite a good point. It's the same breeders breeding for the next generation of seedlings or producing the clones. They have to decide which one is going to win.

Another point I would like to make is as Dr Mohd Noor said, it takes twenty years to get a clone through from selection, initial selection to final acceptance on a large scale but I notice that there is very little use for seedling rubber materials any more, and that is in relatively a short space of time.

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