1. INTRODUCTION

The following thesis deals with the author's two year contract as a research agronomist with the Ministry of Agriculture of the Republic of Malawi, a small nation in Central East Africa. The position was fulltime within the Department of Agricultural Research and had two roles. The first was to fill the gap left by the incumbent Malawian who was undertaking studies in England by taking over the responsibilities of his position. The second was to bring Australian expertise to the position (in particular for macadamia nuts) under the Australian Staffing Assistance Scheme. This unusual situation was used as the setting for an action research project based on the tree nut industries of Malawi.

Some of the difficulties of writing a thesis based on an action research project are highlighted by Perry and Zuber-Skerrit (1990). They highlight the distinction between the core action research project and the thesis action research project. This need arises when the researcher is engaged in fulltime employment (and has the responsibilities that entails) but also uses the work situation as a focus for study. The core project is part of the day to day concerns of the work place. The thesis project studies what happens as a result of the work and seeks to go beyond the performance of these duties to consider the methodologies used and resulting outcomes. The aims are to improve the researcher's skills by reflecting on the process and outcomes, to improve the situation in which the study is conducted and to enhance the understanding of others involved in the situation.
The process and outcomes revolve around the need to improve nut yield and quality with the potential to improve returns for the client group. The problems faced include tree nutrition, irrigation, post-harvest handling, pest control and managing the production system as a whole. A research agronomist would normally expect to confront problems of this type although a specialisation in a particular area such as post-harvest is common in developed countries. The type of work undertaken is outlined in Section 4 as part of a paper presented to industry leaders to explain the approach taken. Not all the problems encountered required trials and the extension effort is not documented.

The thesis project is concerned with ways of dealing with the situation which goes beyond the obvious problems in the production system. The research problem this thesis seeks to address is the need to provide a sound base for research activities and a framework for decision-making about current and future research needs. To achieve this, the thesis must cover a wider area than the core project and seeks to cover the situation as a whole within limits set by the situation encountered. For this reason, the thesis project is an action research type because the author seeks to improve the situation from within while satisfying the normal requirements of his position.

A combination of Farming Systems Research and Soft, Hard and Appreciative systems approaches are used to provide a framework for the study. The holistic nature of these approaches seemed appropriate to the situation encountered. The rationale used to tackle the situation is outlined in the industry paper in
Section 4 and is central to the thesis. This paper was presented after approximately one year's work and was aimed at bringing the client group and co-researchers into the project openly. This was necessary to complete the process of providing a sound base for research activities and to generate debate about current and future research activities.

The study was conducted in different historical and cultural settings from the author's previous experience in Australia and South East Asia. The location of the study and limited resources available meant the author was largely on his own in undertaking the work. This presented challenges and risks which had an impact on the study.

The client group are estate managers since they are the managers of the tree nut production systems and control the tree nut industries. This group are articulate and powerful. They had the means to make or resist changes. An industry body (the Tree Nut Growers Association) provided a mechanism to work through in conjunction with the Department of Agricultural Research for the core and thesis projects.

The structure of the thesis reflects the evolving nature of the work because a pre-conceived plan could not reasonably exist in these circumstances. The Introduction is followed by a short section on The Author's Involvement in Malawi and The Situation Encountered initially. The initial impressions were to set the scene for the study. The Background follows and covers the search for information and ideas to provide a framework to work within. The Background includes sections on plantation or estate agriculture, farming systems approaches to research and problem solving, systems concepts in agricultural settings and
action research concepts. These are related to the situation in Malawi. The next section is the main body of the thesis and contains a paper presented to the industry and other research staff. Although some duplication occurs in this paper with the Background, the majority of the paper is included. The paper contains the approach taken to the core project and is an integral part of the thesis project. It brings the client group into the project in a more formal way, justifies the work undertaken and provides the basis for future work. A brief section follows covering relevant Outcomes flowing from the continuing work on the projects. The Discussion draws together the author's thoughts on the methodology used, and outcomes of the project. Relevant Appendices are included to provide evidence of the work undertaken.
2. THE AUTHOR'S INVOLVEMENT IN MALAWI AND THE SITUATION ENCOUNTERED

The author's involvement arose from an advertisement in the Australian media by an agent of the Government of Malawi. The position was for a 'Tree Nut Agronomist' to undertake research mostly into the problems of the macadamia industry. The position was funded by the Australian Staffing Assistance Scheme (A.S.A.S.). Beyond this, the information available about the position, the work to be done or the macadamia industry was very limited. Cashew nuts were also mentioned as a research area. Extension was not mentioned at all.

The position called for an experienced researcher with work experience in cashews and macadamia, ability to manage staff, provide leadership and to write reports. The position was based at a research station about 30 kms from the nearest main town and the appointee would live on the research station (Bvumbwe Agricultural Research Station - B.A.R.S.). Another A.S.A.S. appointee was to be working on macadamia entomology at the same station. (Mr D.A. Ironside had commenced work a few months earlier.)

The situation encountered in Malawi presented personal and professional challenges. There was no counterpart - the incumbent was in England studying for a Ph.D. at the University of Bath. The author had to fill the position as an inline employee of the Government of Malawi and operate within that system. The incumbent had been away for one year and was not due back until the end of the author's contract at the earliest. Hence, the agronomy section had been without a leader as such for that period and the responsibilities had
fallen on the technical staff. Similar situations were occurring in other commodities as many of the 'professional' staff were away on training.

Macadamia and cashew research in agronomy were part of the Tree Nut Commodity team which also covered pecan nuts, tung oil and coconuts. The Commodity team included entomology and the other A.S.A.S. appointee was the team leader at the time (his counterpart was also away on training overseas). This gave the team an interdisciplinary nature although there was little evidence of cooperative projects. A number of agronomy trials were being maintained or were near completion but there seemed to be little direction for research. The Department of Agricultural Research (D.A.R.) within the Ministry of Agriculture was to conduct research while another department, the Agriculture Development Division (A.D.D.), was to disseminate information to growers. The A.D.D. did not normally deal with the estate sector where most of the macadamia nuts were grown so the Commodity team tended to deal directly with the estates.

Information about tree nuts was generally lacking from a scientific/technical view but information regarding the industry was also lacking. Only a few papers or articles had been written and background data on aspects such as climate, yields, quality and agronomy were lacking. Despite this, estate sector managers were demanding that a range of trials be conducted to solve their perceived problems. The problems were often poorly defined and managers were unable to clearly demonstrate causes of perceived problems.
Resources were very limited with D.A.R. Operating expenses for the Tree Nut Commodity were better than many other commodities but were still inadequate to conduct the amount of work demanded by the industry. Transport was very limited and expensive so conducting field trials off-station was going to be difficult. Day-to-day problems of obtaining such ordinary items as writing paper and stationery were common place. Since A.S.A.S. staff do not come with independent funds (as most other aid projects do) it was necessary to work within the constraints that existed. Estate managers appeared to have little understanding of the realities of government research funding or operational constraints.

Technical staff seemed to be quite competent and had a wealth of useful information. They routinely carried the load of the professional staff in their absence. Their thinking seemed to be limited to certain types of trial activities such as fertiliser and irrigation trials which the industry regarded as important. Such trials are easy to justify at project meetings where D.A.R. officials review work undertaken and approve future budgets. The Commodity team members had tried to cooperate with industry but felt that estate managers took little notice of their input. Since they were all Malawians and the estate sector managers were almost all non-Malawian and predominantly white European or African, it appeared that cross-cultural problems still existed. Estate managers appeared to feel superior, with technical staff acting in a subordinate and inhibited manner in their presence.

Most research in progress was directed towards macadamia. Tung oil was a dying industry and maintenance of clones was
B.A.R.S.' main role. Pecans were grown on station but were not important commercially. Coconuts were just beginning as an observation crop, located in the Northern Region, well away from B.A.R.S.. Cashews were important but received little attention due to transport problems in reaching growing areas. The main macadamia area (except for the large, single planting in the Northern Region) was close to B.A.R.S. The trials in progress included a plant growth regulator trial, using Cultar (Plactobutrazole) which supported the incumbent's studies in the U.K.; a young tree nutrition trial using various rates of nitrogen, phosphorous and potassium; a rootstock/scion trial using locally derived rootstocks; a clonal trial involving the four clones most in use, two introduced clones of Hawaiian origin plus a locally selected tree. The macadamia trials were replicated at Lunyangwa Research Station in the North or at Mzenga/Kawalazi estate in the North. A cashew selection trial was established at a small research station in the lower Shire River valley named Kasithula. Pecan trials consisted of an observation and yield recording exercise on a small clonal planting.

The research underway had serious deficiencies which meant that a number of trials were a waste of time. For example, a nutrition trial at Kawalazi/Mzenga in the North had not received any of the fertiliser which was the basis of the trial although the trial had been in place for seven years. The clonal trial at Lunyangwa had missing replicates three years after planting - there was very little funding to run the Lunyangwa trials.
Research direction presented a complex problem. The research unit had tried to respond to industry demands in the past and they were still endeavouring to do so. Some past trials had been failures but the industry demanded more of the same. Some examples were an irrigation trial which had not shown any conclusive results; a nitrogen/phosphorous/potassium (N.P.K.) trial which had actually reduced nut quality; an N.P.K. trial on young trees to get increased growth where yield and quality appeared to be the problem, not growth. Some eight irrigation trials based on estates were proposed but the actual climatic and soil data had not been quantified to see if irrigation was really required. Similarly, the N.P.K. trial had been using rates of fertilisers which were very high and a control of no fertiliser was not included. The industry had demanded that no control be included because they felt all trees needed fertilizer. No standard leaf levels for the N.P.K. elements were used and the rates of N.P.K. were based on coffee, a heavy feeder. It was clear that the background information relating to the prevailing field conditions had not been quantified.

Until these factors were put into perspective in relation to the production systems being used, research would lack the necessary background information to give clear direction.

The macadamia industry is based in the estate sector. The 'estate sector' or 'plantation sector' consisted of large land holdings, most of which existed before independence and are controlled by large, U.K.-based multi-national companies. One was a locally based multi-national but still had strong links with the U.K. The predominant crops were tea and coffee, with
tung oil a declining industry. Although the hectarage was often large, macadamia was a very small crop in the overall estate production systems. Macadamia was usually planted on poorer land not suitable for tea or coffee, or as a replacement for tung oil trees. Macadamia was seen as a diversification crop, sometimes even planted as a boundary marker to prevent land encroachment by surrounding villagers. Managers' knowledge of the crop appeared limited and interest was moderate, although increasing with recent high prices for kernel. Trees were commonly grown without a management plan, and usually received the same treatments as neighbouring coffee (commonly used as an intercrop in macadamia) or tung trees on an ad hoc basis. The condition of field trees was highly variable and productivity and quality seemed to be low.

Stepping onto an estate was like stepping back into a novel about Africa in 1920. Managers often referred to themselves as 'tea planters', lived in large houses with staff, had beautiful gardens and so on. A very simplistic approach to crop management seemed to exist, summed up by the comment from one estate manager "you can grow tea by the calendar". A labour intensive approach was used in every aspect of operations, although the labour was largely untrained and worked in poor conditions. Many practices were a shock to see. Although 'tied labour' (a system where workers who live within an estate boundary had to contribute free labour to the estate) had been abolished with independence from the United Kingdom some 26 years before, most workers did not appear to be much better than slaves. Wages had just doubled but still only amounted to about $0.80 cents Australian per day. Women and children received less and made up a large part of the workforce,
usually on a casual basis. The technology used in macadamia production was very limited, for example, dehusking was commonly done by a person using two stones. The dehusking machines that were in use were very inefficient and damaged the nuts. Spraying practices for large trees included knapsack sprayers or backpack misting machines and appeared to be highly inefficient as well as dangerous to the health of operators and the environment. Managing the labour force seemed to be the main day-to-day issue with making a profit the aim in the production system.

Smallholders, a term used to refer to farmers on a small area of land, were often mentioned but rarely seen. A small number of smallholders delivered nuts to the factory but were insignificant in terms of total production. Other smallholders in the Bvumbwe area had access to the factory but one had actually removed most of his trees because he did not trust the factory after payment for the initial deliveries he made was too slow. A number of smallholders were known to exist at Nchisi but they were not part of the commercial system. Some nuts were sold on the 'black market' by smallholders and this was also thought to be an outlet for nuts stolen from estates.

The other major issues confronted initially were those of power and the hierarchical and rigid nature of the government and private systems. In the government system a position carries certain powers and the rules and regulations are strictly adhered to. Questioning superiors or decisions from above is not condoned and a person who steps beyond the bounds is very quickly put in place. The control extends as far as all
correspondence going through the officer in charge of B.A.R.S. who decides if the correspondence can proceed and ensures the 'chain of command' is respected and adhered to.

Malawi is a one party state with a Life President where power is viewed in absolute terms and authority is generally not questioned as the consequences are severe.

In the estate sector power in the macadamia industry clearly rested with one estate - the Naming'omba Tea Estate (N.T.E.). This group had the processing plants for macadamia and tung oil. N.T.E. had made most of the money from macadamia through superior tree productivity and control of the factory and the marketing. N.T.E.'s influence extended into the informal sector - the Tree Nut Growers Association (T.N.G.A.), and the formal statutory body overseeing the nut industries - the Tree Nut Authority (T.N.A.). The Chairman of N.T.E. had a very powerful personality and could dominate proceedings at meetings, even though he was not actually a member of either body. He used his power base to further the company's interest and friction with growers who were unhappy with the situation was obvious. N.T.E. had made a considerable investment in macadamia compared to other growers and gained the benefits.

There were many obvious problems in the production system, some easy to overcome, others less so. A strong extension effort would be needed, but what about research? Two years is a short time in the life of a tree crop such as macadamia and although many research possibilities existed, a plan was required which had a clear direction for research activities. The industry lacked information and focussed on simplistic 'technological fixes' such as the application of a growth regulator like
Cultar to overcome their problems. However, the problems where more complex than that. D.A.R. expected research results, the industry wanted quick fixes while A.S.A.S. wanted counterparts to be trained. Funding was very limited, ideas entrenched, power established and the time short. A plan was needed to tackle the situation to make a worthwhile impact. It was apparent that the approach taken would have to operate at many different levels concurrently to satisfy the different aspects that required attention.

Two connected areas of concern were emerging where the author felt he could have an impact. One was the production system problems, a natural concern for a research agronomist; the second, perhaps more important in the long term, was the need to provide a sound base for research activities and to generate debate about research activities. As a newcomer to the situation, the first area of concern was the easiest to tackle and fitted the job description. The second was considerably more difficult because information was lacking and the author would have to challenge the status quo in order to make changes. It would be necessary to gain the confidence of others in the situation and proceed with caution before any major changes were implemented.

Having broadly defined the problem areas, the next step was to provide a framework to worth within. A Farming System Research approach combined with systems approaches appeared to offer a means of dealing with the complex situation. The author decided to utilise these to clarify the situation and proceed from there. Planning beyond this seemed premature until more information was available and the author was accepted by others in the situation.
3. BACKGROUND TO THE PROJECTS

Plantation or Estate Agriculture

Since the major client group were estate managers information was sought, from literature and people involved in this sector, to provide a historical perspective. Coming to terms with the way in which the sector operated and the reasons for this were necessary to be effective in the position of research agronomist.

The General Manager of N.T.E. in discussions in October 1989 indicated that estates exist on freehold or leasehold land and many have existed since the 1920's or earlier and hence well before independence (Emmott, 1989). Unlike many African nations, little attempt has been made to change this system in Malawi. Thomas (1979) traces the development of the plantation economy in Guyana from colonialism and slavery to control by multinational companies prior to nationalisation. This has many parallels with Malawi. Large scale farming enterprises exist amid a basically subsistence economy with the benefits in general flowing to European controlled companies and individuals. Similarly Ghai and Green (1979) describe the estate sector in Tanzania before the Ujamaa village concept was introduced.

The general characteristics are similar - large pools of cheap labour and land resources farmed for profit. The system has developed from slavery to tied labour to paid labour but the production systems are still based on cheap labour and land with an extensive approach to production. The estates in Malawi appear to have a corporate parent and management
structure and conservative production systems based on hand labour for the majority of operations. Mechanisation was at a low level in Malawi. Mr J.W. Ching'ani, Senior Technical Assistant for Tree Nuts, in discussions during 1989 described his country as "the last bastion of colonialism". However, the National Statement of Development Objectives 1987-97 (Kak hobwe 1989) gave estates an important place in the economy, despite what Thomas (1979) describes as extensive exploitation of labour and land. The F.A.O.'s "S.A.D.C.C. Agriculture 'Towards 2000'" (1984) gives the following description of the dualism apparent in the Malawian situation -

"The colonial era from which S.A.D.C.C. countries have recently emerged led, however, to an economic structure characterised by an unbalanced form of dualism. There was a vigorous growth sector, usually centred around extractive industries and estate agriculture. Growth in this sector originated from foreign demand and was reflected in the incomes of a middle-income class of managers and a high-income class of expatriate entrepreneurs. The structure of development in this sector was, in turn, oriented to meeting the consumer demands of the managerial and high income classes it comprised, mainly through imports but also through import-substituting activities, including modern agriculture.

The subsistence sector, on the other hand was the traditional economy, linked to the growth sector only through the provision of labour which was generally paid minimum incentive wages...Little trickle down of growth took place, because the linkage mechanisms between the growth sector and the subsistence sector were weak or non existent,
consisting mainly in manual labour, the rates of which did not increase to reflect productivity increases of development in the growth sector. Although overall development took place, at times rapidly, the subsistence sector was left behind."

There are conflicting views on plantation agriculture and the problems associated with it. Batten (1954) traces the development of the plantations and the effects this had on the indigenous people. Of particular concern in Nyasaland (Malawi before independence in 1964) was the movement of able-bodied men away from the village and the effect this had on village life and agricultural productivity at the village level. The cheapness and unskilled nature of labour was seen as inhibiting real development by limiting the adoption of improved technology. Similarly, the benefits to villages were small because wages were low and the workers often spent the money before it reached the village. Batten also traces the uneven development pattern where capital was concentrated on small areas for the benefit of the investor. The impact of money, wages and money taxes causes a complete change in values of people in the village system. This was not seen as positive, adversely affecting food production and forcing villagers to generate income to meet monetary needs from a subsistence economy.

Plantation agriculture emerged from the background of colonial interests. Beckford (1976) traces the economics of plantation agriculture and describes a sorry picture. Although many of the references are from the Caribbean, he also cites African examples. His primary concern is that the benefits of plantation type agriculture flow to consumers, generally in metropolitan areas or overseas and less to the local economy.
This can have a detrimental effect on small local producers and subsistence farmers. Low wages lead to limited flow-on for local development and the increasing vertical integration of multinational corporations contain the benefits within a foreign dominated structure. These groups become largely self-serving and self-contained. Batten and Beckford both point to instances of plantations destroying small farmers in competing countries, for example rubber in West Africa by Asian based plantations.

David (1986) traces the rise of transnational or multinational corporations in agriculture in developing countries. He points to issues such as benefits to host countries and of the weak bargaining positions of developing nations. He concludes that - "while there has been some change in attitudes over the years, it can be commented that the typical foreign investor does not normally perceive its role in terms of the total development of the host country, but rather from a more limited perspective of generating tax revenue that could then be used to finance plans for national development. While this is a rational response, the total tax take available to host countries depends on how the firm makes its pricing and cost allocations among affiliates in several countries... host countries may lose substantial revenues."

Amin (1977) takes a social perspective to emphasise the benefits of rural hard work flowing to urbanised people and the exploitation of rural workers by the capitalised class. Although presented with a clearly socialist bias, he outlines problems of structural adjustment and of the limited power of rural people in dealings with the owners of capital and
national policy makers. The socialist experiment in African countries and elsewhere is steadily falling so the enthusiasm for Marxist socialism is difficult to justify.

On the other hand Graham and Floering (1984) from Graham's experiences of plantation agriculture with the Unilever Corporation, paints a much rosier picture of plantation agriculture. The authors concentrate on plantation agriculture only and are not writing from a development perspective. Graham considers that the emerging plantations can and do contribute successfully to host countries. He feels a closer study of 'modern' plantations is needed because these are very different from the connotations of the early history of plantations. He points to instances where smallholders and large plantations co-exist for mutual benefit.

Characteristics of plantation (also called industrial agriculture) are traced through a series of definitions. From Beckford (1972) comes the following ..."Plantations differ from other kinds of farms in the way in which the factors of production, primarily management and labour, are combined. The plantation substitutes supervision - supervision and administrative skills - for skilled adaptive labour - combining the supervision with labour whose principle skill it is to follow orders."

Graham gives the main features of plantation agriculture or corporate agriculture as: a large labour force; extensive land areas; skilled management; close supervision for a system of detailed routine; export of the product. Others could be added depending on the situation but in general, a production line approach is emerging similar in nature to large
scale factories in industrialised nations. Some examples are
given which would not find favour with environmentalists, for
example ..."oil palm in Sabah, East Malaysia - 6,650 hectares
carved out of virgin forest." He goes on to emphasise the
important linkages which exist with local economies and how he
feels the situation has improved in recent years. Graham also
makes much of the application of research to the production
system in plantation agriculture.

The objectives of plantation agriculture appear to be different
from domestic agriculture and a question must be raised as to
the suitability of macadamia as a crop. Macadamia is generally
regarded as a luxury horticultural product, not a commodity.
Given the profit motive, the management style and internal
rigidity of the production systems employed, fitting macadamia
production into this system and improving yield and quality
would be a challenge.

In Malawi, research on the major traditional crops such as tea
was conducted in expatriate controlled research institutions
such as the Tea Research Foundation (T.R.F.) which received aid
from foreign governments (usually the British Government since
this was the base of most of the estate holding companies).
According to the Director of T.R.F., foreign aid is still the
life blood of T.R.F. along with estate contributions. (Grice,
1989). The Malawian Government does contribute (such as
through the Coffee Contract Research) but the (Deputy Chief
Agricultural Research Officer still regarded T.R.F. as a
'colonial' organisation. (Ngwira, 1989). Attempts to support
the development of horticulture in Malawi led to foreign aid
personnel placement at Bvumbwe Agricultural Research Station
(B.A.R.S.) in the early 1950's. Macadamia research started this way with two English horticulturalists (A. and O. Spurling) funded by the British aid agency, forerunner to the current Overseas Development Agency (O.D.A.). B.A.R.S. annual reports (1968-75) give references to macadamia research by the Spurlings, mostly on basic propagation. In this way, the link between B.A.R.S., macadamia and the estate sector was formed. The involvement of expatriates continued with the appointment of an entomologist funded by O.D.A. (Mr E.C. LaCroix, 1979-87) and, more recently by A.S.A.S. in 1989 with Ironside (entomologist) and the author.

In discussion during 1989, the former Deputy-Director Research at T.R.F. expressed the view that the estate sector was conservative, the education standard of managers generally low and understanding of research and adoption of research findings within the production systems employed was low. This had resulted in much frustration on the part of researchers at T.R.F. (Clowes, 1989). Similar sentiments were expressed in discussions with research staff at B.A.R.S. who felt estate managers did not take much notice of their ideas and considered this to be a manifestation of social superiority on the part of the estate managers.

Farming Systems Approaches

A farming systems approach is often used in developing countries to define research and development issues in agriculture. The complexity of the situation and lack of background information indicated the need for a farming systems study to clarify the situation and give direction for the
future. Virtually all farming systems literature dealt with small farmers or farm households, not estates. However, Norman and Baker (1986) and Gerhart (1986) felt that both small and large scale farmers could benefit from a farming systems approach and that the 'human element' is one of the main features of this approach. Gerhart points out that the approach will not of itself "solve the problems of allocation of resources toward larger, more capable, more powerful or more advantageously placed farmers."

But what is a farming systems approach? A number of descriptions exist, often relating to specific parts of the concept or to variations on the main ideas. Norman and Baker (1986) present farming systems approaches as a philosophy rather than a strict set of guidelines, because the situations encountered can be so varied. The general ideas of the approach as outlined by Norman and Baker arise from failings in conventional research approaches to farmers' problems and the failure of many rural development aid programs. The lack of consideration for the "human element" or "the engine of development" is generally given as the major failing of such programs. Hence, the importance of the human element in farming systems approaches which seeks to ensure two way linkages among the various participants in the research process through a pragmatic bottom-up orientation. However Flora-Butler (1982) and Remenyi and Coxhead (1985) report similar approaches emerging much earlier in United States Land Grant universities and in Australian research in agriculture, forestry and soil conservation. These initiatives also confronted the equity issue although in a different context with different social and cultural perspectives.
Norman and Baker (1986) provide two developmental strategies for a bottom-up farmings systems approach:

1) Farming Systems Research (F.S.R.), where the aim is to develop and disseminate relevant improved practices (technologies) through the conduct of on-farm research and with farmers.

2) Farming Systems Perspective (F.S.P.) where the aim is to influence the development of policies and support systems that create an incentive structure for the adoption of technologies that will improve the productivity of farming systems, with existing or new technology.

Gerhart (1986) gives the following description of F.S.R. as used by some international research centres, in particular the International Centre for Arid Region Dryland Agriculture (I.C.A.R.D.A.) in Syria:

"F.S.R. is a process that identifies problems limiting agricultural productivity and then searches for solutions to these problems. This process recognises the resources and constraints of the farming families (who are both producers and consumers) and seeks solutions that are relevant, useful and acceptable to these families. Research is undertaken by multidisciplinary teams of scientists that interact continually with the farmers for whom the research is intended. This approach should ensure that research produces appropriate technologies and therefore will be more easily and quickly adopted."

Gerhart goes on to discuss the emphasis on research to increase farm productivity in international research centres. In doing so he indicates that their mandates and nature can be
restrictive. Farming systems research in various forms is now entrenched in most of these centres.

Two similar generalised outlines exist for F.S.R., that of Shaner, Phillip and Schmehl (1982) and Worman, Norman and Ware-Snyder (1990). These are quite similar, each involving a series of steps. Shaner et al propose 5 steps as follows:

1) Target and research area selection.
2) Problem identification and development of a research base.
3) Planning on-farm research.
4) On-farm research and analysis.
5) Extension of results.

These were features of a method termed Farming Systems Research and Development (F.S.R.& D.) designed for aid workers in Africa. Worman et al proposed a four step methodology (as used by Norman and Baker earlier) which listed the following stages:

1) Descriptive/Diagnostic.
2) Design.
3) Testing.
4) Dissemination.

Both methods are iterative and all steps need not be followed in all cases, especially where obvious improvements can be made. However, to implement fully, considerable resources are needed to operate a multidisciplinary team. The basic idea is to start with an identified target group, examine the existing production system while collecting as much information as possible from available sources, identify problems and devise experiments to overcome these (or use existing technology if available), test the proposed solutions and then give the resulting information to the target group. Both groups of
authors provide considerable detail from experience in the field of the use and application of the techniques involved. In both cases the target groups are small farmers.

Norman and Collinson (1985) give a theoretical and practical background to F.S.R. approaches. They argue that F.S.R. approaches are complementary to technical component research (T.C.R. - the usual disciplinary based, controlled research activities) and have three connected functions:

- A mobilising and adapting/adopting role whereby existing knowledge accumulated through T.C.R. is used to provide technical solutions for the target group.
- The identification of problems used in setting T.C.R. research priorities.
- Nurturing links with farmers and extension staff to draw them into the technology generation process.

Other farming systems ideas include Farming System Research and Extension (F.S.R. & E.), outlined by Hilderbrand & Poey (1985). A generalised process of six steps is given which emphasises flexibility and farmer first orientation but with a sound scientific backup. The method is essentially similar to those outlined by Shaner et al (1987) but has an extra step which formalises the feedback loops before final presentation of information to the target group. This allows researchers to redefine the problems and improve recommendations and helps with future research needs. Rhoades and Booth (1982) present a farmer-back-to-farmer model, which has four steps with a goal for each step written in terms of the farmer, ending with farmer evaluation of the researchers' ideas. The authors state the model does not contain the depth of scientific methods
outlined in other approaches but is a philosophy and a set of guidelines for effective interdisciplinary research. The assumption is that until farmers have evaluated the proposed technology, all scientific evaluation remains at the level of hypothesis. This contrasts with T.C.R. where the testing of the hypothesis by the scientist is the basis for success or failure. Socio-economic aspects are highlighted in the farmer-back-to-farmer model and it presents a humble, people oriented approach rather than the vigorously "scientific" type commonly found in International Agricultural Research Centres. The other main research/extension/farmer models (such as top down and feedback models) are given in the ASPAC Seminar Proceedings of Applied Agricultural Research for Small Farms in Asia (1985).

A number of similar approaches but with different emphases are also available, including Agroecosystem Analysis as outlined by Conway and Barbier (1990). This gives a set of guidelines for working with groups of farmers with three broad steps covering pattern analysis, development analysis and implementation. Although directed at a multiple cropping pattern in the examples given, the studies consider horticultural crops whereas most others do not. Hart (1986) describes ecological aspects of multiple cropping including the importance of hierarchical agricultural systems which start from organs within organisms and go through to world economies. The methods outlined above have more emphasis on the nature of agricultural systems than F.S.R. by studying broader relationships including the linkages between farming and ecology. They seem less appropriate with the limited resources available and the job description of the agronomist.
Beets (1982) gives a detailed rundown on cropping systems and tropical farming systems which includes research methodologies. Some confusion exists between cropping system research and farming system research. Zandstra (1977) indicates that cropping systems research concerns itself only with crop production activities and not with research allocation between the farm's production and consumption activities and, therefore, considers existing resource inter-relationships between these activities and the crop production enterprises as given. However, the techniques outlined seem appropriate in setting research priorities once background information is gathered and these are the first steps of a farming systems approach. Harwood (1983) sets out a conceptual framework by having physical factors (e.g. light, land and water), economic factors (e.g. markets, power, cash and labour) and production technology (e.g. crop variety, insect management, fertility, disease management) integrated through systems technology into alternative cropping patterns leading to improved farmer welfare. Such an approach is clearly aimed at productivity of a given crop within a set of existing relationships.

Numerous constraints were identified in the various versions of farming systems approaches. The paper by Birgegard and Fones-Sundell (1987) gives a good overview of the problems of various methods available. Institutional constraints are mentioned in most F.S.R. papers. There are two cases were an ad hoc farming systems approach can be justified - the first being where there is a general lack of knowledge about farming systems employed (which fits the macadamia industry in Malawi); and the second is when a particular research problem is of great importance and the need to solve the problem very strong,
then the process used to solve the problem is of secondary
importance.

It appeared that an ad hoc farming systems approach would suit
the situation in Malawi - an approach rather than a strict
methodology because a full scale study was beyond the time,
resources and competence available. The approaches value then
was a broad, open-minded way of looking at the situation within
the limits of the resources available and job description
constraints. The two general ideas of improving appropriate
technology and affecting policy could be translated into three
areas of action - immediate problems to be tackled with
available information or good guesses, a situation analysis and
development of a good data base to find out what was really
happening; and providing a sound basis for future research
work.

**Systems Concepts in Agriculture**

The term 'system' has been used repeatedly so far but what is a
system? Spedding (1988) discussing agricultural systems lists
some thirteen points about systems, many of which relate to
descriptions of a system by modelling. The following are
considered to be relevant to the research in Malawi:

1) Systems are identifiable entities with important
properties and attributes that are quite distinct from
those of non-systems.

2) Systems can be of any size or complexity, from a molecule
to an elephant or a universe, and any system can be either
a component or a subsystem of another system.
3) When a system is a component of another system it has specific inputs and outputs resulting from its interactions with the rest of the system: an independent system is not bound by such interactions.

4) In practice, no system is completely closed or completely independent but the differences between an object as a component and as a system are usually very large.

5) All systems can be modelled but it is not always practicable to construct a model at any given level of detail.

7) Models should always be capable of validation and where possible, should be validated.

9) When systems are too large and too complex to be studied in their entirety, subsystems that can be usefully studied separately, may be identified.

13) Improvement (or indeed any response) of a system, due to changes in one or more components, cannot be predicted without the use of a model, of some kind, representing that system.

In studying systems in agriculture he puts two important questions:

1) What is the system to be improved?

2) What constitutes an improvement?

It is necessary to define the system and have an understanding of that system before the second question has any relevance. For example defining the production system for macadamia and providing background information to gain an understanding of that production system is a starting point to answering the second question. A criteria against which to measure an improvement is required. This needs to be an objective measure
such as an improvement in yield and quality of nuts on-farm to satisfactorily answer the second question.

Spedding goes into detail on systems modelling and description, experimentation with systems components, the value of a scientific approach and testing of hypotheses related to specifics about a system. A useful section concerns ways of monitoring a system. Monitoring is a useful way of information gathering about a system as well as a way of following changes resulting from intervention in a system. The industry in Malawi lacked formal monitoring (or at least obvious monitoring) procedures, and information about the situation was limited. Spedding also points to hard systems and soft systems concepts.

Hard systems have clearly defined objectives and measures of performance and deal with ideas such as the physical production of a product. Soft systems deal with people and as such cannot be optimised in the same way as a hard system. The concept of soft systems is important in dealing with managers since they are people and not a production system, but controllers of production systems (or hard systems). Checkland (1981 and 1988) devised a soft systems methodology to deal with problem situations involving people, mostly in social corporate structures. Checkland (1988) gives an overview of Soft System Methodologies (S.S.M.) as a way of dealing with ill-structured situations, which deal with people and for which no optimum or fixed solution exists. He gives the following outline of the outcomes of the methodologies in a learning sense:

1) In S.S.M. "the system is not some part of the real world but is the organised process of inquiry itself."
2) The concept system is not a label, a word for something in the perceived world, but is an abstract concept which can be used to help make sense of the world.

3) Given its nature as a system of inquiry, the use of S.S.M. has to be participative. The role of the expert in S.S.M. is best thought of as helping people in the situation carry out their own study.

4) Thus users of S.S.M. should not try to create and preserve its status as a body of professional knowledge. They should be trying to give it away to people in problematical situations.

In this way S.S.M. is about structuring debate about situations to be improved, about problem owners, problem solvers and about merging to find common ground through debate in a social context. These ideas seemed relevant in dealing with thinking about research within the industry. However, criticism exists of S.S.M. Rosenhead (1984) looks at the work of Checkland and some contemporaries in the field and considers the approaches too idealistic. By this he means that they do not seem to consider the prevailing state and power politics involved - that the methodology has a regulative nature of maintaining existing states, maintaining the status quo. This is important in the Malawian context where power is evident and forcibly exercised. Jackson (1982) presents detailed argument about soft systems thinking, which forms the basis of Rosenhead's thoughts to some extent, although the maintenance of status quo is a main theme in the discussion.

In relation to agriculture, Holt and Schoorl (1985, 1986 & 1989), examine conventional ideas in agricultural research and extension. The final paper looks at three paradigms for
putting ideas into practice, appreciative systems, soft systems and hard systems. They are critical of the ready acceptance of system approaches of agriculturalists and stress the need to place more emphasis on the role of power and regulation. These ideas are drawn largely from the works of Vickers. Checkland and Caesar (1986) present an analysis of Vickers' concepts of appreciative systems from which they highlight some major recurring themes of Vickers' thinking.

- a rich concept of day to day experienced life as a flux of interacting ideas and events
- a separation of judgements about what is the case 'reality judgements', and judgements about what is humanly good or bad, 'value judgements'
- an insistence on 'relationship maintaining' as a richer concept of human action than the popular but poverty stricken notion of goal seeking
- a concept of action judgement, stemming from reality and value judgements
- a notion that the cycle of judgements and actions are organised as a system.

Holt and Schoorl (1989) give Vickers' own description of appreciation as "the exercise through time of mutually related judgements of reality and value". In the Malawian context, a concept of an appreciative system and concepts of power are very important, especially when viewed from the author's work situation. The author is confronting a situation where a long history is established of judgements, and established norms in the macadamia industry. Power clearly resides in certain quarters, and the human element will be the largest impediment to change. Holt and Schoorl see appreciative systems operating
at all levels of the process of putting ideas into practice, while the roles of soft and hard systems act through the appreciative system in particular areas. Hence, their approach formalises the role of appreciative systems as an active part in what is happening all the time, which can influence and guide actions through time to arrive at changed situations or act to maintain the status quo, depending on the situation.

**Action Research**

A unifying theme in the material discussed so far is the active participation of the researcher in the situation being studied. A broad farming systems approach, utilising systems approaches and studying the situation as part of that situation, are all somewhat different from the role of a traditional scientist who studies a phenomenon but is abstract from it. In this sense (and because the situation is also a learning experience) the project undertaken is an action research one. Kemmis (1988) traces action research back to the work of Kurt Lewin in the 1940's. Lewin was a social psychologist who was interested in applying experimental techniques to social science problems. The idea was to integrate theory and action to stimulate social change in a self-informing process where a series of cyclic steps are repeated. Foster (1972) quoting Eberh (1968) gives the following definition of action research:

"action research is where the researcher has the same kinds of concerns as the operational researcher, although in addition he sets about introducing and observing change while exploring solutions."

Grundy (1982) lists three forms of action research, namely technical action research, practical action research and
emancipatory action research. The first is concerned with techne and is characterised by a pre-determined aim to create and produce something. The second type is concerned with praxis which seeks to improve praxis through the practical skills of the participants. The third type is concerned with critical intent which integrates theory with practical judgement, through reflection, to develop critical theorems. However, most of the literature available relates to educational and social science examples whereas action research is written in terms of social situations and change. Bawden and Macadam (1988) applied action research ideas to agricultural education and to agriculture in general. They consider action research projects to exist where "the focus of action is to solve a problem or improve a situation, and the research is the conscious effort, as an outcome of the process, to formulate concepts and generalisations that can be applied in other situations." Four outcomes are seen as results of a successful action research project:

1) The practice of the action researcher will be improved.

2) The action researchers understanding (theory) of the practice will be improved.

3) The situation in which the practice is practised will be improved.

4) The understanding of all those involved in the situation in which the practice is practised will be improved.

Macadam, R. (1991 pers.comm.) believes writing action research projects as a thesis present problems and few examples of such projects exist in an agricultural setting. Perry & Zuber-Skerritt (1990) considered action research projects in a graduate management program. They suggest a combination of a
core action research project and a thesis action research project. In this mode, both the client group's concerns can be met as well as the researcher's needs. In a broad sense, this approach can be applied to the situation in Malawi where the improvements in the production system appeared to be the main concern of the client group, whilst establishing a sound basis for research decision making, the author's concern. There are problems with this approach because there is considerable overlap between the core and research projects. The need for performance in a work sense is strong. Other concerns are also important including justification of research results to D.A.R. where expectations are different from either the client or the author per se.
4. REVIEW PAPER PRESENTED TO INDUSTRY

The following paper was presented to the members of the Technical Liaison Committee, the T.N.A., the T.N.G.A., estate managers and co-researchers in September 1990. The paper has the same title as the thesis and is included in the thesis in the same format as presented. Minor changes have been made to the paper for inclusion in the thesis. Major changes would have altered the nature and intent of the paper which is a central part of the thesis. The paper sets out the approach taken to the core and thesis projects and the justification for these. The paper draws on F.S.R. and systems approaches and attempts to define the situation at the time of presentation utilising those methods. The paper is related directly to the macadamia situation and the work undertaken by the author during the first year of the author's contract. The aim was to integrate the ideas, thoughts and actions of the author with the other players in a more formal way. The paper goes well beyond the requirements of the position of the research agronomist and is a central part of the thesis for that reason. The author feels the paper is necessary to clarify the situation for himself and others and to lay the foundations for the second part of the project.

The paper was forwarded to the members of the Technical Liaison Committee and co-researchers ten days before a meeting of the Committee in September 1991. This was to allow the members time to read and digest the material to facilitate discussion at the meeting. The author then spoke to the paper and issues raised at the meeting. Discussion lasted over three hours and the members agreed to distribute the paper further to all
relevant company directors and to take a number of resolutions to the members of the T.N.G.A. These resolutions included "Was the paper a true and accurate assessment of the situation" and "Was the approach taken in the paper a good basis for setting current and future research needs." Members of the Committee appreciated the chance to get involved and actively debate the issues in an open forum where the benefits to the whole industry were concerned and not clouded by company or personality restrictions.

It should be noted that some repetition will be encountered in the paper with the Background section in the thesis. This is unavoidable in preserving the intent of the paper as outlined above.
Towards a Farming Systems Approach to Tree Nut Research in Malawi

Background

Tree nut crops have had a chequered path in Malawi. The main areas of interest at present are Macadamia (*M. integrifolia*), Cashew (*Anacardium occidentale*) and Tung (*Aleurites fordii*), although Tung has been declining for some time and the existing oil extraction processor has given notice that they will cease to process in 2-3 seasons time. Other nuts are Pecans (*Carya illiniosensis*) and Coconut (*Cocos nucifera*) but these have not yet reached commercial development and are at the stage of preliminary research.

Of the above crops, macadamia was recently the most important with approximately 1,800 hectares planted (about half of which are producing) and a further 1,000 hectares is currently planted or is in the process of being planted based on N.T.E. records from Mr E. Myenza (Executive Secretary, T.N.A.). The majority of plantings are estate based (i.e. based on large commercial holdings with traditional crops of tea, coffee, tung, tobacco and fuel wood) with a very small area of smallholders in the Bvumbwe, Ntchisi, Mzuzu, and Nkhata Bay areas. A single processing facility exists at Naming'omba Tea Estate in the Thyolo area which currently processes and markets the kernel in Malawi and for export.

Cashew development has been concentrated on the lakeshore and Shire Valley but has so far failed to be a major crop. Two large estates and a few smaller plantings exist in the Mangochi and Salima areas. A recent Food and Agriculture Organisation
and Admarc (a parastatal buying and selling organisation for smallholders) initiative to encourage smallholder plantings has met with limited success. The area planted and bearing are not known and current production is small.

Tung plantings for oil production are being phased out in the estate sector and are no longer considered an important crop. Mr C. Barrow (Chairman N.T.E.), speaking at a T.N.G.A. meeting in December 1989, stated that an initiative by the processor to stimulate planting about 5 years ago failed and the processor has given notice of its intention to cease processing. This situation appears unlikely to change and very little attention is being given to tung other than maintaining clonal material.

The Statement of Development Policies 1987-96 (Office of the President and Cabinet, Kakhobwe 1987, p.66) gives macadamia and cashew as the main development thrust. Some 16,000 hectares have been identified as suitable for macadamia and the value of the crop as an export income earner is important. The main emphasis is seen on the estate sector but smallholders potential will be explored. Cashews are seen as a way of utilising lower altitude lakeshore and Lower Shire Valley areas where the income earning potential of traditional crops is low. Smallholder potential is highlighted.

Research activities will be concentrated on macadamia and to a lesser extent cashew as a result of the above perspectives.
Macadamia Research

Macadamia research (and other tree nut crops research) is conducted by the Department of Agricultural Research within the Ministry of Agriculture. The main centre is Bvumbwe Agricultural Research Station in the Southern Region and a small program is conducted through Lunyangwa Research Station in the Northern Region. Trials are conducted on station and on estates. The research team is an interdisciplinary one of agronomy and entomology. A professional officer for each discipline and support staff (technical officer, technical assistants and labourers) are the personnel assigned to the team. Support staff have been relatively stable but professional officers have tended to be less so. Currently, both Malawian professional officers are undergoing Ph.D. training outside of Malawi and are being replaced by Australian Technical Assistance Scheme personnel.

A number of existing trials are underway and further work is envisaged although some rationalisation appears necessary. A review of the agronomy research to date was conducted by the tree nut agronomist (Mr W. Hancock). Initial work concentrated on observation of tree survival, fruiting in this environment and propagation techniques. Later work looked at clonal selections, nut abscission, nutrition trials and irrigation trials as well as plant growth regulator studies. A review of entomology research was conducted by Mr D.A. Ironside and found the main aim of this work had been to identify casual agents of kernel damage and their life cycles and some control measures were recommended.
Cashew Research

Cashew Research has been much less intensive. Mr I.M.G. Phiri in B.A.R.S. Annual Report 1987-88 reviewed the situation and highlighted a number of limiting factors including lack of uniform and high yielding cultivars, poor nutrition of trees, pest and diseases and poor cultural practices. These have resulted in very low yields and a very low return on cashew trees planted. Some initial entomology work was conducted to identify pests and test possible control measures.

Although some doubt exists regarding methodology of trials, in particular irrigation and nutrition, the research appears to have been reasonably well conducted. There are two underlying problems however; one is that there are questionable premises behind some of the work given the available information elsewhere and second, that within the industry there appears to have been a very low adoption rate of research ideas and findings.

In addressing these, it would be useful to look at a wider view of the industries and the roles and relationships with research and extension in Malawi. The reasoning behind this is fairly simple - all factors (i.e. estates, smallholders, researchers and extension personnel) are operating within a broader context or system and there should be an understanding of that system and of the implication for individuals within the general framework for individuals or organisation to be effective. This paper will concentrate on macadamia.
Some Industry Observations

The following observations are based on interaction with industry people, researchers and extension agents, available literature, and field observations:

- macadamia has not been considered a major crop. A number of estates and smallholders actually removed trees due to low return and slow payment from the factory pool in the early years of processing but recent high prices have stimulated a broader interest.

- as a minor crop, macadamia did not receive much attention, commonly intercropped with coffee where the coffee was the important crop.

- those estates which gave the crop sufficient interest have generally done well from the sale of kernel and obtained good production.

- management strategies for macadamia have been largely based on the traditional crops (tung, tea and later coffee).

- estate managers are usually responsible for many crops, so time for any one crop can be limiting.

- management strategies have tended to be oriented towards management of the labour force rather than the crop itself (due to a large, unskilled labour pool). Estate managers tend to be well removed from actual field operations because of the management structure required to manage the labour force.

- the level of technology employed has been very low resulting in inefficient cultural practices (examples are tree spraying for insect control with backpack mist blowers on large trees and dehusking machines which damage the nuts and
are only partially effective in removing husks). The reasons for this relate to the low priority of the crop, a large cheap labour pool, a hesitancy to invest in capital equipment, a failure to keep track of industry development in other countries and cropping strategies (e.g. intercropping and utilising non-tractorable land) which make mechanisation of key cultural practices such as insect and disease control difficult.

- a lack of understanding of the nature of the plant has lead to cultural practices detrimental to tree health, and nut quality (e.g. continual hoe weeding and fertiliser practices).

- a lack of information available to researchers and industry about the crop in general, plus a lack of base data on the plant in this environment.

- ineffective use of (or lack of understanding of) feedback from the factory assessment information by estates and researchers.

- researchers with limited funds and back up services to conduct trials and operate as effective extension persons.

- a lack of continuity of research staff has tended to limit effectiveness of trial work.

- a smallholder component of the industry virtually forgotten by all sections of the industry including research.

- some recent initiatives of the Ministry and growers to improve the funding situation are in progress (i.e. World Bank loan funding for a research proposal and an increased grower commitment).

- recent re-establishment of a joint research/grower technical committee to foster links and give direction for future
activity (Tree Nut Growers Association Technical Liaison Committee).

- a general agreement by Government and industry that macadamia is an important export income earner and will become a more important crop to both estates and smallholders in the future (as evidenced by a recent initiative by Government to the African Development Bank for funding for a feasibility study of smallholder industry for macadamia).

A Broader Approach - Considering the Farming System Perspective

The above observations are general and are by no means a complete analysis of the past and current situation. They are a useful starting point for this discussion of future directions and for developing a wider perspective (or model) of the industry. For research purposes, current and future work should fit in with the broader industry aims. Hence it was necessary to initiate some basic data collection and analysis to provide a clear picture of the industry and allow a reasonable model to be developed. Spedding (1988) emphasises the need to have a familiarity with the system being studied which is essentially what has taken place thus far. Spedding goes on to point out that it is essential to understand a system before one can influence it in a predictable manner. Implicit in this notion is that a system is recognisable and has a boundary which can be defined. Mr W. Hancock (Tree Nut Agronomist) indicated, at an industry seminar in March 1990, that growers need to have a more holistic approach and a better understanding of the whole production system.
In attempting to define boundaries for an industry model, the Technical Liaison Committee of the Tree Nut Growers Association has agreed that processing and marketing will not be covered by the committee and hence the boundary has been set at the factory door. However, it must be remembered that the information feedback from the processor and also from the eventual market place is extremely important to the grower and must influence research and production system decisions. Hence, the boundary of the system at the factory door is an arbitrary one which reflects a 'natural' industry boundary.

Bysouth (1985) points to the broader socio-economic and political influences on a production system, in particular, those of small farmers and farm workers. Whilst these issues are outside of the scope of the technical liaison committee, they are important issues which affect the production system. Policy in these areas can affect the implementation of changes (e.g. wages policy influences incentives for Integrated Pest Management pest monitoring scouts; wages policy and the black market for nuts influences level of theft from orchards). Again the boundary around the farm itself is an arbitrary one which can be set in order to limit the extent of the model/system as a useful starting point.

Spedding (1988) poses two questions which need to be addressed. These are:

a) What is the system to be improved?

and

b) What constitutes an improvement?

In the above, 'a' has been defined as the onfarm or whole farm production system; 'b' is somewhat less obvious at first
glance. Nuts have to be processed to utilise the kernel (i.e. removed from the shell) and this can be expressed as a mathematical relationship and graphically represented. The equation is

$$x = \frac{a \times 100}{y} \frac{1}{1}$$

where \(x\) = quantity of nut in shell; \(a\) = kernel recovery in kilograms; \(y\) = percentage (%) kernel recovery (i.e. weight of kernel over weight of whole nut expressed as a percentage) and is represented in Figure 2 (see page 47). As you move along the \(y\) axis starting from zero, the quantity of nut in shell decreases as kernel recovery increases at a given level of kernel produced. Kernel is the saleable product from nut production in Malawi. Thus, an improvement in kernel recovery for a given quantity of nut in shell will result in an increase in kernel and could be seen as an improvement in broad terms. However, kernel quality is also an important factor because kernel is sold on a quality basis. Kernel quality is dependent on visual appearance (colour, wholeness and freedom from damage or discolouring) and an objective floatation test for oil content (e.g. kernel with >72% oil float in fresh water) which is used to grade kernels in terms of grades 1, 2 and 3 as well as wholes, halves and pieces. Therefore quality needs to be considered in the improved equation. An improvement in the overall production system would then be viewed as 'an improvement in kernel recovery and quality.'

Similar techniques have been used in other industries where a total yield is misleading as a measure of improvement. Schatzko (1985) found fruit size in apples to be the most important factor in improvement of grower returns, which
Figure 1 - A simple model of an estate macadamia production system and influences upon it.
Figure 2 - Quantually nut in shell required to give 100 kg of kernel at different percentagge of kernel recovery.

\[ x = \left( \frac{a}{y} \right) \times 100 \]

\[ y = \% \text{ Kernel Recovery} \]

\[ x = \% \text{ Kernel Recovery in Kilograms} \]

\[ x = \text{Quantity of Nut in Shell} \]
affects the way the farm is managed to regulate fruit size. Having a single factory with a kernel recovery and quality analysis service is an advantage and provides a valuable monitoring and feedback service. Similarly, a wide range of onfarm practices affect kernel recovery and quality adversely so this measure provides an objective way of monitoring improvement at various levels in the whole system and subsystems.

It should be noted that there are many possible changes or improvements which will not necessarily have a measurable affect in kernel recovery or quality but would still be considered desirable practice for other reasons. Tree mulching and herbicides to control weeds instead of hoeing is an example of this. Similarly, improvement in a subsystem such as the nursery is important in improving the quality of trees reaching the field and establishment of these trees which will affect later productivity but this will be difficult to measure in kernel recovery and quality. Some research activity such as basic data collection and analysis does not of itself lead to measurable improvements, but can do so as time progresses by utilising the information in trials. Gaining insights into the system is a necessary step towards measurable improvements.

It should be noted also that there are smallholders who are not yet part of the system even though they have nuts which could be processed. This is a complex problem and one which has to be addressed at various levels including Government and Admarc. The Technical Liaison Committee and the research and extension staff have a duty towards long term improvements in the
situations for smallholders and this should be borne in mind in formulating policy and research directions.

The diversity which exists in the industry at present (i.e. from a small farmer with a few trees and virtually no inputs to a large estate with a large planting of hundreds of hectares and a high level of inputs in comparison) make a complete model difficult because it cannot cope with the diversity encountered. However, compared to a 'western' high technology mechanised approach, the estate sector still relies on a labour intensive approach which tends to indicate that their production system is more of an expanded smallholder type than the emulation of western-type systems. This is particularly important because it indicates that direct transfer of high technology solutions is unlikely to work but improvements made to the existing system could be more easily transferred to smallholders. Thus, the existing estate system can be a useful initial proving ground and filter for technology developed for both estates and smallholders.

Norman and Collinson (1985) have given the following definition of farming systems research as

1) the development and dissemination of relevant improved technologies and practices;

2) the implementation of appropriate policy and support system to create opportunities for improved production systems and to provide conditions conducive to the adaption of technologies already available.
Similarly, they view this approach as complementary to technical component research (or disciplinary based research) with three parts to that role:

1) to look at the stock of materials and techniques accumulated from technical components research and to choose technical solutions to problems. Onfarm experimentation then adapts chosen solutions to the local situation. This is a modifying and adopting role, finishing the product (the product being the information or technique and the market being the target audience of farmers, or managers within the industry or community) for an identified market; and

2) to report back unsolved problems to the technical component research team. This helps fix priorities for future research; and

3) to maintain links with farmers and extension staff in local farm situations, drawing both farmers and extension workers into the technology generation process.

It can be seen then that the more holistic approach takes a broader view than the purely disciplinary view, which it encompasses, and can provide a framework for decision making and monitoring changes in the system, utilising as much of the available information and technology as possible. The reason for using this approach is to try to avoid the research bias of disciplinary persons who tend to concentrate on their own area (which is perfectly natural given their interests and training) and lead to imbalanced or impractical views of what should be done. An example of this in Malawi is the influence visits by outside experts have had on research directions. Professor
Allan from South Africa (University of Natal, 1986) provided a summary of possible areas for improvement and research. In attempting to utilise the reports, growers and researchers seized upon various ideas some of which were impractical in the actual setting of estates and smallholders. The use of intermittent misting to reduce leaf temperatures is a good example. Such a technique is feasible under ideal conditions in a laboratory or very controlled field experiments but virtually impossible in an actual field. Thus, there is a tendancy to concentrate on areas of specialisation (Professor Allan is a Plant Physiologist) rather than what could be a broader, more generally applicable view.

The C.A.R.O., Dr G. Mkamango indicated in 1989, that limited funding for research in tree nuts eliminates most basic research. Similarly, the size of the industry means that industry contributions to research are small and not sufficient for basic research. However, Australia and to a lesser extent Hawaii and South Africa, are conducting basic research on macadamia which can be utilised in Malawi at little cost. Adaption will be required but that is to be expected. Having a good understanding of the situation to which it is to be adapted is really the key to the success in utilising such information.

Thus, concentrating on areas where information and technology is available, adapting these and effectively implementing these will be more useful and cost effective than performing basic research out of interest. The exception to this approach is where basic information is lacking (such as the phenological cycling of macadamia in various environments in Malawi) which
limits the ability of researchers and managers to adopt useful information and technology.

An Industry Model (estate sector) for Macadamia
(see Figure 1 page 46)

Models are infinitely variable according to the maker and the purpose. The aim of this model is to identify the boundaries, subsystems, feedback loops and flows in the onfarm production system and from external sources. The kernel recovery (and quality) function is a way of monitoring the effectiveness of the production system and changes in it in a quantifiable way. It can be used to stimulate management towards changes because a value can readily be attached to it. Also, this feedback can give an indication of the areas of improvement needed or where problems are occurring. The processor does the marketing and receives feedback from the market which is filtered through to the onfarm management. This (which includes a price for kernel) will affect overall estate management plans as well as day to day management of the production system.

The subsystems onfarm were defined because each has distinct functions and locations. A number of possible problem areas can be directly attributed to those and they tend to be managed onfarm as discreet units. They may have off farm functions such as a nursery supplying other growers with trees to generate income or field trees may be intercropped with coffee or chillies for sale not through the macadamia system but which will affect the management of those trees. Individual farms will vary and isolating a subsystem for more detailed study can
give further insights important in that context, e.g. the effect that intercropping with coffee has on macadamia yield.

The reasons for having 'hard' and 'soft' systems in the model is that the hard system components can be viewed differently from soft system components. A hard system can be seen as having definite outcomes (such as to produce a product) and can be analysed and optimised in some ways to meet a set of objectives (Checkland 1988). The production system can be seen as a hard system for this reason (optimising kernel recovery and quality from a given area of trees could be an objective which could be measured and monitored) but actually managing that hard system is a human activity and is classified as a soft system. This distinction is particularly important because soft systems cannot be optimised since they deal with people and values which are outside of a set of objectives common to a hard system. Research and policy decisions must take account of the fact there are many ways to view a problem and that managers will vary considerably in their approaches and ideas. Implementation of proposed changes will be affected by this and any research which does not have a wide possible or probable use base is difficult to justify in the Malawian context. Whilst an attempt is not made here to analyse the soft systems involved in detail, they are part of the system to be studied and improved. As stated in the observation about the industry, the large and generally unskilled labour force is a definite soft system type of situation when it comes to implementing a change to the production system which requires a change in the level of skill of workers. Just managing the labour force is a difficult area in itself.
Areas of Concern or Possible Problems

The model given is a simple one which only defines the general pattern, flows and subsystems. It does not of itself define problem areas. An attempt to quantify general problem areas was made by Hancock, Banda and Ching'ani (1989) by using the feedback loop from the processor to growers. There were a number of purposes behind this. First was to relate kernel problems seen in the factory to the production system. Second was to demonstrate to managers the usefulness of this feedback as a management tool and the third was to have a method of monitoring changes in the situation which could be related to intervention in the production system. This largely reiterated the observations of others (Allen 1986-87) but went further by attaching a monetary value to losses and an order of magnitude of losses. These are useful to managers and researchers and provide a data base for monitoring future changes.

The main findings of this study were as follows - bug damage (piercing and sucking insects) 37% of total losses; nut borers, 9.2% of total loss; rancid/discoloured and mouldy, 24.4% of total loss; Grade 3 kernel (i.e. kernel with <65% oil content and not saleable kernel in Malawi), 27.9% of total loss and small nuts, 1.5% of total loss. The value of the loss in monetary terms was MK 1,310,444.00 compared to an industry sale value of approximately MK 3,100,000.00 based on price of saleable kernel. These are areas of immediate concern which relate to the production system as it exists now. Since all these problems or similar ones have been faced by other nut industries overseas, technology may be available to make
significant improvements although it may not be directly transferable.

Another area of concern that became obvious during the recent period of rapid expansion was the production of good quality plants for field plantings. Many estates had problems in producing grafted plants in sufficient quantities and of reasonable quality to satisfy the planting programs. Again, nursery technology is highly developed elsewhere but not necessarily directly transferable.

Further areas of concern are the lack of basic data about the crop in this environment. This relates in particular to tree performance (measured total productivity and resultant actual production), clonal performance, economic analysis, climatic analysis and industry monitoring systems relating to these as well as nutrition, pests and diseases. Making changes to the production system or directing research are difficult if this information is lacking and trying to quantify a 'success' or an improvement is impossible if there is nothing to compare it to.

Finally, the aims and objectives of the estates' management need to be quantified, not just in terms of maximising profit or returns but in broader terms such as to what extent they are prepared to change the management of the production system to accommodate a technology or a different approach. A good example of this is spray technology. Few estates are able to efficiently apply chemicals for insect control. The technology is available to improve the efficiency but an investment decision and a willingness to make the necessary changes to accommodate the technology into the production system is required. These are part of the management function (a soft
system in the model) and for those managers unwilling or unable to improve application efficiency, improved technology per se is not an option at all. It is necessary to have a good idea of the way managers think to overcome such difficulties and provide enough options to cover the likely target groups. Securing the confidence of managers in research staff is essential as a starting point.

It is necessary to take note at this stage of the likelihood of some conflicts arising from changes in research ideas and also of implementing a change in approach or later, in the production system. The Technical Liaison Committee has the potential to be a forum for debate on these matters, to provide a framework for policy ideas and a humanising filter to pass research ideas through. In this way, the Committee can take into account the technological issues (hard systems), provide a forum for debate on the situation in question (soft systems) and make decisions which account for the value judgements of managers which will affect the implementation of ideas and technologies (appreciative systems). This is similar to the view of Holt and Schroot (1989) who put forward a cosmology for putting ideas into practice in an agricultural context. Starting from an engineering perspective (which they use as analogous to hard system methodologies) of a design process to meet a specific end, they move towards an agricultural model which adds sociology as part of the process of implementing change, the result of scientific research. These processes are seen as complementary and adds a broader approach to the engineering model, by including the human element. The reason for this are that the assumptions involved in hard systems (goal seeking, solutions and optimisation) are not necessarily
valid for human behaviour and, as agriculture is a human endeavour, something further is required to accommodate the human element (i.e. soft systems which can accommodate different view points and allow debate about the situations in which changes may take place). To this framework they add the consideration of value judgements or appreciation which Vickers (1965 - from Holt and Schoool 1989) describes as 'the exercise through time of mutually related judgements of reality and value." An appreciative system is about regulation of existing states and norms, of relevant relationships, and value judgements, and is open to change based on these as they currently exist. The appreciative system is the filter through which the other systems operate and the final outcomes will be a result of the judgements made in this way.

These considerations are very important and will determine the success or failure of possible changes before they get to the field in many cases. Implicit in the above is also the matter of power. Authority and influence are part and parcel of the situation whether derived from a structural source such as the Tree Nut Authority or from another source such as personality or commercial clout. These could be part of the appreciative system or may be outside the general situation but can impinge upon it. Onfarm managers are subject to decisions made by estate managers and company directors which may or may not be favourable to the onfarm production system. Research staff are employees of the Malawian Government and decisions which affect their activities can occur at any time and will have an effect on the research effort.
Utilising a Farming System Approach in Nut Research

Much of the documented farming system approaches have dealt with smallholders (Birgegard and Fones-Sundell 1987) and has not been applied to intermediate areas such as estates. Farming systems approaches are part of the Australian research effort in helping agriculture, forestry and soil conservation (Remeny and Coxhead 1984) and in the U.S.A. (Flora-Butler 1982) and in most industrialised nations the growing environmental awareness has lead to a more holistic approach to agriculture and research activities. A multi-disciplinary approach is common place such as used in B.E.T. analysis in Sweden, i.e. Biological Economical and Technical analysis of horticultural firms (Carlson, Christensen and Nilsson 1979). So, the multidisciplinary or interdisciplinary aporach with the producer as the centre of the situation is a holistic model applicable to a wide range of possible producers, be they smallholders or estates.

The term 'farming system approach' is used because the methodologies involved are still evolving, depending on the situation being examined. Shanner et al (1982) produced a handbook for development workers using a farming systems approach which they called "Farming System Research and Development". They listed five steps as basic activities:

1) Target and research area selection
2) Problem identification and development of a research base
3) Planning onfarm research
4) Onfarm research and analysis
5) Extension of results.

These relate primarily to small farmers using onfarm research techniques supported by off farm staff and facilities. Worman et al (1990) presents a more generalised framework of four stages:

1) Descriptive/Diagnostic
2) Design
3) Testing
4) Dissemination.

This involves examining the current farming system as the starting point using the body of available knowledge from as many sources as possible, proceeding through experimentation and testing stages leading to the development of a modified farming system for dissemination. Both the approaches offer a fairly similar methodology under different names. Apart from providing for a holistic approach with the producer or farmer as the consumer of improved technologies, they allow the application of scientific knowledge and principles to farmers problems. Spedding (1988, p.99) expressed the view that agriculture is not a science but involved the application of scientific knowledge and principles. Implicit in this view is that there are many other aspects to agriculture which are not scientific and farming system frameworks provide a way of accommodating these whilst making use of science. Spedding also points out that "if a hypothesis to be tested scientifically is to be useful in agricultural practice, it must relate to a recognisable agricultural system or to a sufficiently independent part (or subsystem) of one. Furthermore, this relationship must be explicit in the
statement of hypothesis". Research must have a clear focus to be useful.

Although the target group is largely estates at this stage, the information and technology developed and adapted for this group has application in the smallholder situation. This is true for only some of the technology but information leading to a better understanding of the trees in this environment and under certain management systems will be needed to develop the smallholder sector. There are problems in trying to apply a single methodology in the Malawian context because all methodologies need a certain level of financial and institutional support to be effective. The effective use of resources is extremely important for two reasons. One is that resources are very limited and two, is that the estates are putting forward a considerable amount of funding towards research. Thus the institutional constraints must be balanced with the target groups needs and the allocation of funds and time done accordingly. The farming systems approach is a good way of doing this by utilising the T.N.G.A.'s Technical Liaison Committee as a forum for growers ideas and concerns to be considered by researchers. This body can also provide a continuity of research to some extent by the funding and through liaison with the researchers. In the light of these considerations, a farming systems approach can provoke an 'academic' view (such as the use of models) to provide future directions for research. It also encourages the more action oriented onfarm research with a farming system perspective which can proceed as quickly as possible to onfarm experimentation and adaptation of technology in association with the target group.
The model of the estate production system for macadamias and the kernel recovery function were given to the estate managers on the Technical Liaison Committee. Five questions were asked in relation to their views as to where they see the problems within the production system as presented and their views on broader industry and management issues as well as what they see as the role of the Technical Liaison Committee. These views are a necessary part of the decision making process and are central to a farming system approach. These views will be considered and incorporated at a later stage but the current research should be considered as it is at the moment to see how the current work fits into the broader perspective.

Current Agronomy Work

This includes ongoing and some, more recent, additions and is not presented in any order of priority.

1) Title : Macadamia Cultar Application Trial

Objectives : To evaluate the effects of Cultar (paclobutrazale 20/10 201), at different rates, on vegetative growth, nut retention and yield of macadamia

This is an ongoing trial commenced in response to industry and chemical company interest in chemically controlling tree size and improving yield. The work is at a very early stage and is supporting Ph.D studies of Mr I.M.G. Phiri in the U.K. (the Malawian incumbent Tree Nut Agronomist). Considerable interest was generated in the use of Cultar by seminars conducted by the chemical company promoting its use but very little hard data exists as to its actual effectiveness, rates of application,
side effects and field use in macadamia. Some estates experimented with Cultar also and observations of these indicated a very variable response. In terms of likely use in the industry, it is a long way from the recommendation stage. Current work will give indications of the physiological response to Cultar of the clones of macadamia it is being used on. The commercial adaption of plant growth regulators has had a chequered career and the adaption of Cultar in the existing type of production system is problematical due to the cost, effects and need for accuracy in application. However, detailed observation of treated and control trees will give some insight into the physiology and phenology of the trees in the site environment. Similarly, controlling tree size is a worthwhile practice since trees are large relative to productivity and pest and disease control is difficult. This presents an option for growers and should be continued until the findings from Phiri and Banda are available.

2) Title : Phenological Cycling of Macadamia within the Malawian Environments

Objectives: To define the phenological cycles of macadamias growing within the different growing areas in Malawi. To relate the phenology of the tree to the management needs of the crop and make recommendations based on these.

This trial is based on a simple observational technique used to quantify the plants response to the environment in terms of vegetative and floral patterns. When this is known, management strategies can be defined accordingly and a management calendar
produced as a manager's guide. The information gained is also
of use in designing future research and making recommendations
on cultural practices. The work has only just commenced and
will take about 5 years to compile a reasonable amount of
usable data. However, it is a low input trial based on regular
field observation of the same datum trees that are used in the
entomology trials so does not require a high level of input.

3) Title : Nutrition of Macadamia in Malawi

Objectives : To define the current nutritional status of
macadamia by leaf and soil analysis.
To devise recommendations and result
demonstration trials based on the above.

Probable nutrition disorders were thought to be causing yield
and quality problems so this work is in response to that. A
preliminary report was released and a set of recommendations
given to the industry, modified to individual estates in some
cases. A result demonstration trial was initiated early in
1990 but discontinued later. This was because of funding cuts
and a lack of control in the field work. Instead, a monitoring
system has been established for the effects of the general
recommendations via the use of leaf analysis and the
quality/yield assessment data from datum trees in association
with entomology. Using recommendations in this way is much
like a super-imposed trial because the grower implements the
recommendations and the research staff monitor the results.
This allows the researchers to cover a large number of sites
with minimal inputs and does away with the costlier researcher
controlled onfarm experiments. So far, the industry have been
very responsive in implementing the recommendations. Leaf
analysis conducted inside and outside of Malawi has confirmed some of the feelings of the preliminary report - notably low Potassium and very low Boron levels were found. Discussions with Dr K.Klaus of the Kali and Salz Ag. Ltd Buntehop Agricultural Research Station, West Germany, confirmed that in the oil producing crops he has studied, there is a relationship between level of oil accumulation in the seed and the level of Potassium in the plant tissue. There is a reasonable amount of published information about macadamia nutrition from Australia and Hawaii and appropriate leaf levels have been set. It seems reasonable to define existing leaf levels and make recommendations and monitor the changes in quality rather than conduct nutrition trials which would try to duplicate sound research done elsewhere. This approach is also much faster and the impact should start to be seen in the 1990-91 factory figures.

4) Title : Investigation on Nut Quality Problems

Objectives : To define the causes of nut quality problems in nuts delivered to the factory.
To relate the problems to individual estates and implement improvements.

The results from the 1988-89 season have been completed and the 1989-90 season is almost completed. The 1988-89 season provided useful factors to where immediate action could bring about improvements in the production system, particularly insect control, post harvest (dehusking and drying) and nutrition. Similarly, when a value was attached to the losses, managers were surprised at the magnitude of the problems but also had a set of figures to use for decision making, e.g. the
losses for insects could be balanced against the investment required towards more efficient spray equipment.

As stated earlier in this paper, these figures utilise the feedback loop from the processor to estates. Estates have not made much use of this information but it can provide a direct measure of the cost of losses and a way of monitoring improvements. The work to date has been very useful but it is not seen as being necessarily a research task on a long term basis. Managers should be able to collate and interpret this information as it is seen as a useful management tool. The researchers can get benefit from monitoring the changes and relating these to individual estate problems. About 4 seasons should be analysed by researchers and then managers can do their own which researchers can help interpret and make recommendations from.

5) Title : Tree Size Yield Relationship
   Objectives : To establish the relationship between tree girth, ground canopy area and yield of saleable kernel in different clones at different sites.
   To make recommendations on clonal suitability and the management of tree size in this environment.

In conjunction with entomology, this study was carried out on datum trees of each clone at each site and uses the quality analysis data from the trees done at Bvumbwe Agricultural Research Station. The reasons for this work are to get a clearer picture of how clones are performing at different sites, how productive they are, how much return they are
giving, how different sites compare and to have a base to compare improvements in the production system against. This base can also be used to compare newer clonal material with existing clones.

This is basic data gathering to form part of the research information base. Information of this type is lacking for macadamia but is necessary for decision making about current problems and future direction - i.e. you need to know what the current situation is in order to move towards some improvement.

The data is currently being analysed but the following generalisations can be stated. There is a wide variation between sites, with those sites which have had a reasonable level of management input doing much better than the others. There is a small variation between clones at each site in terms of yield of nut in shell but differences in kernel recovery of saleable kernel (and hence returns) make total yield a poor measure of real productivity. Yields per tree vary from virtually nil to quite high (up to 65 Kg nut in shell at 10% moisture content) but with the exception of two sites, yields are low by world standards. Productivity is generally low in the early years and overall tree size is not a good indicator of likely yield. Trees are generally larger than comparable trees of the same age in Australia indicating the natural soil fertility or induced soil fertility by added fertilisers. This has not resulted in increased yields and add weight to the field observations of the need to improve nutritional management of the crop.
This type of study should be conducted every few seasons (e.g. every second season) to monitor changes. New clonal material should be rated in a similar way to gain a valid comparison with existing clones. More accurate estate records would be useful as well since variation in tree age and management practices make comparisons between sites difficult.

6) Title : Dwarfing Potential of Three Selections at Bvumbwe Agricultural Station

Objectives : To investigate the dwarfing potential of three selections in the seedling block at Bvumbwe Agricultural Research Station.

A block of seedling macadamia (about 700 trees) at Bvumbwe Agricultural Research Stations provides a sizeable genetic pool. Observation of this block revealed a considerable variation between trees including three trees which appear uniformly small for no obvious reason. A number of intermediate size trees exist as well. Currently, there are no documented dwarf macadamia trees. However, a considerable amount of basic research is needed to prove the trees are genetically dwarf (or why they are physiologically or physically dwarfed) and if they are useful as a rootstock, or as clones in their own right. This would be a sizeable program on its own and is probably beyond the current resources available. Current work is aimed at defining yield, quality and sizes of the trees and their responses to improved nutrition in the field. These trees will also be included in future clonal trials (those which show promise) to gain further information. At this stage, no further work is planned beyond this unless specific funding is available.
7) Title : Supplementary Irrigation on Macadamia

Objectives : To define the climatic and soil data and stress periods at different growing sites for macadamia in Malawi.

To make recommendations on supplementary irrigation requirements for different sites and give direction for future research.

This program has been completed and the results presented to the industry at a field day on Nasonia Estate on 2nd August 1990. A very detailed analysis of the climatic factors was conducted by Mr W. Banda. Soil samples were taken and analysed at Bvumbwe Agricultural Research Station for water holding capacity. The results were presented in table form where rainfall and soil water reserves were balanced against likely amounts of irrigation required. The results indicate that the window for irrigation is quite small for a perennial tree crop and the quantities not very great. Given available information from Australia (in particular Trochulias 1987 and 1990) and the results, it is thought that further work on irrigation in most sites is not warranted and would not be cost effective. A useful side benefit of this study is to more clearly define possible growing areas for macadamia in Malawi and where irrigation is likely to be required beyond the establishment phase.

8) Title : Macadamia Production and Pest Management Manual

Objectives : To review current practices of macadamia growing in Malawi.
To produce Production and Pest Management manuals in light of the above and available information.

This program is aimed at providing a set of management guidelines for the crop, covering agronomic, post harvest and pest management practices. It is to be produced in a loose leaf form which can be updated as required when more information is available. There is currently no set of guidelines of suggested good practice for macadamia in Malawi. Much of researchers' time is spent providing this type of information which could be better spent elsewhere. Hence, updating the information base would be of use to estates and Agricultural Development Division (A.D.D.) extension staff in decision making without a personal visit being required by a researcher in each case. It is hoped to complete this in the next 12 months. An English and possibly a Chichewa version for A.D.D.s and smallholders is envisaged.

9) Title : Economic Analysis of Macadamia Growing in Malawi

Objectives : To establish gross margin and development budgets for estate and smallholder macadamia growers.

To use the above for cost/benefit analysis of current practices and future research.

This work is in the preliminary stages and will take some time to complete. Since virtually no information is available from the smallholders, it is difficult to make much progress in that regard. For estates, Mr M. Simpkin of Blantyre and Eastern
Africa Co Ltd is doing a development budget for establishing a macadamia orchard. Gross margins and cost/benefit analysis are difficult because of the wide variation in productivity of estates so a meaningful budget is not easy to arrive at. This is further complicated by the estate sector emphasis on other crops and by budget restrictions placed on them from external sources (e.g. the company headquarters). Hence, a report on these is not expected for some time and other economic indications arising from the factory figures and tree size/yield relationship will provide short term directions.

10) Title : Macadamia Clonal Trial 2
Objectives : To evaluate growth, precocity, yield and quality of several 'new generation' clones in relation to selected old clones from Clonal Trial 1.

Finding clonal material suitable to the Malawian environment is very important. As recent investigations have indicated (tree size/yield relationship) the current clones are not performing exceptionally well. This trial is being expanded with further introductions from Australia and by a more detailed evaluation of existing seedlings at Bvumbwe Agricultural Research Station. The genetic material at Bvumbwe Agricultural Research Station has potential and should not be ignored - preliminary quality analysis of 200 seedling revealed 3 trees of high kernel recovery and grade 1 percentage (i.e. over 40% and 85% respectively). This is superior to the existing clones in use and these trees have survived and produced with minimal care in the Malawian environment. Further study of these trees and the rest of the seedlings is warranted.
To date, the clonal material is only just commencing bearing and results will not be available for a few seasons.

11) Title : Macadamia Scion-Rootstock Interaction Trial
   Objectives : To study compatibility and performance of several scions on different rootstocks.

There is very little published information regarding rootstock scion interactions in macadamia. Studies in this area take many years to get results and are difficult to analyse. However, the current trial is in the ground and the trees should commence bearing in the next few seasons and data can be collected from this. Similar studies are underway in Australia. This work is ongoing.

12) Title : Nursery Management and Propagation Manual
   Objectives : To provide basic nursery management and propagation manual for estates and Agricultural Development Divisions to help upgrade nursery management and propagation skills in the estates and other horticultural fields.

This arose from two areas. One being the difficulty some estates were having in producing reasonable quality macadamias for their planting program and second, from problems the A.D.D.s were having in providing grafted plants to smallholders of a range of species other than macadamia. A manual was written and used in conjunction with a training course and follow up visits to participant nurseries. Apart from these visits no further work is envisaged on this. The manual is
available as a ready reference to participants and others are using it as well such as the cashew estate in Mangochi. The manual can be translated, added to and adapted as required to the prevailing conditions.

Whilst the above trials are what is current, others have recently been completed. This list does not include the other activities which take place. Considerable amounts of direct extension to estates (and occasionally to smallholders) is undertaken. The Tree Nut Authority requires site inspections for registration of growers and this takes time. Involvement in Tree Nut Authority meetings and Tree Nut Growers Association meetings also takes time as does the usual administration requirements of the Government. A large amount of time and effort was put towards funding proposals to the World Bank. Hence, the research team has responsibilities beyond the listed trial work and this must be considered in future priorities.
Current Entomology Trials

1) Title: Macadamia Integrated Pest Management (IPM)

Objectives:
To develop and implement an integrated pest management program for estates and smallholders.

To minimise yield losses resulting from pest damage and to improve the harvested quality of macadamia by economic and environmentally sound management strategies.

Pest damage accounts for large field and factory losses in nuts. Past spraying practices have been ineffective in controlling the major pests and have probably led to an adverse effect on beneficial insects. It is necessary to be able to quantify the pest complexes to allow an IPM program to be implemented effectively. This program has been underway for over a year and has produced useful results. It is conducted onfarm and uses the estate labour as much as possible. A side benefit is the training of estate staff in monitoring techniques for macadamia pests. Adapting the IPM approach used in Australia to Malawian conditions is the long term aim of the program. This should result in more effective insect control and a decision making system based on monitoring pest levels. Ineffective spray application is a major problem for the program because of the use of small equipment such as mist blowers against large tree sizes. The trial has been expanded to include aerial spraying and Pyrethroid free blocks to gain more information.
2) Title: Macadamia Flower Pest and Disease Control
Objectives: To compare the efficacy of several test fungicides applied alone or in combination with an insecticide for control of flower blight, lepidoptera larvae, black citrus aphid and broad mite.
To determine the optimum timing of pesticide application using the monitoring and action levels being developed in the integrated pest management program.

This is a trial arising from the IPM program where the cool misty weather which commonly occurs in Malawi at flowering times results in fungal and insect infestations on the flowers. The result of this trial will become an integral part of the IPM program. It is hoped to get assistance from a pathologist for this work.

3) Title: Biological Control Possibilities for Macadamia Pests
Objectives: To determine the effectiveness of existing biological control agents in suppressing pests.
To determine the potential for introducing, mass rearing and releasing parasites or predators for key pests.

Considerable natural parasitism has been observed in macadamia pests in Malawi and this should be utilised in the IPM program. Similar work is being undertaken in other Southern African areas and the information arising from these should also be useful. This type of research is important from an
environmental standpoint (reducing the use of chemicals) but has considerable practical value since actually applying chemicals is a problem, hence avoidance of spraying using mobile natural agents to control pests becomes more feasible and cost effective.

4) Title : Pesticide Application

Objectives : To improve pesticide application effectiveness by improved spray coverage and proper spray calibration.

This has arisen from the fairly haphazard application of chemicals leading to possible environmental dangers and limited effectiveness in pest control. Application rates based on canopy volumes calibrated with the type of applicator are being determined.

5) Title : Efficacy of Pesticides against Macadamia Nut Borer (Cryptophlebia sp) and Stink Bugs (Nezara sp, Bathocuelia sp).

Objectives : To compare the efficacy of 2 new insecticides using two levels of each, with standard insecticides cypermethrin and fenitrothion, in controlling nut borer and bugs.
To screen other candidate chemicals for controlling nut borer and bugs.

There are two aspects to this program. One being the registration requirements of the Government in relation to chemicals (3 years of data is required for registration) and the second being the need to test candidate chemicals for
efficacy for future use. This is ongoing type of research and is leading to possible use of 'natural' pesticides such as Neem oil (derived from the seed of *Azadiracta indica*, Neem, which grows well in the hotter areas of Malawi) and could be grown in Malawi as an industry.

As with agronomy, the trial work as such is not all that the entomology group does. The IPM program involves a large researcher controlled onfarm trial (much like the result demonstration technique of research/extension) which requires a large amount of on the job training for estate based pest monitoring scouts and management staff in pest monitoring, identification and decision making based in monitoring results. This is vital to the successful implementation of the I.P.M. program. Field days and formal training courses take a great deal of preparation time. The entomologist is currently the commodity team leader which means that a large amount of administration time is required. The intensive nature of the research controlled trials means the number of sites has to be limited and the time available for other activities is then less. However, until the IPM program is established on the test sites, there is no obvious alternative to this approach although the pest management manual will help. Some basic research such as the identification of the pest complexes is proceeding on a limited basis which is a limiting factor to the development of long term pest management strategies.

Where Current Research Activities Fit Into a Farming Systems Perspective

The Tree Nut Commodity Team was set up in 1983-84 to concentrate on tree nuts and has always been an
interdisciplinary team (entomology and agronomy). The extent to which the researchers integrated trial work is not clear but from the annual reports of Bvumbwe Agricultural Research Station it appears this was limited. This would have lead to lack of focus and a scattering of effort along disciplinary lines. The current program is attempting to overcome this by using a shared approach to data and trial sites, with increased efficiency and better uses of resources. Interdisciplinary teams are an integral part of a farming systems approach. Similarly, much of the previous research has been conducted onfarm, also an integral part of a farming systems approach. So, a farming system approach has some history if not formally executed and it should not be that difficult to formalise the process with the current research. Using the steps of Shaner et al as outlined earlier, the following would apply:

1) Target and research area identification

Clearly, the estate sector macadamia producers (and where possible smallholders) are the target group as this is where the crop is grown. At a later stage (e.g. when positive moves are in place for the development of smallholder industry) some further stratification may be needed due to differences between the target groups. The national development strategies as outlined earlier also target this sector.

2) Problem identification and development of a research base

Many possible and obvious problems have been identified in the agronomy and entomology spheres but few have been identified as management problems (e.g. low kernel recovery from high grade 3
and bug damage are examples of the former, low level of capital investment is an example of the latter). This has limited the effectiveness of the program because the research has probably missed the most important point, i.e. who is going to use the information generated; are they willing or have the capacity to utilise the information? It is particularly important such questions be considered if an effective program is to be implemented, e.g. high technology options are of little value where a low capital investment approach is used by managers.

Problems and opportunities are identified and ranked in some order of importance. Short term problems in Malawi were placed in an order by the analysis of the factory figures which gives a measure of actual losses occurring at the factory. Hence insect damage, nutrition and crop management, and post harvest handling were identified as the immediate and obvious problems. This is not a very wide view though and does not give much insight into why these particular problems are occurring, where longer term gains can be made or where the most widely useful options could be found. For this reason the development of a research base is particularly important. Short term problems can often be tackled immediately (as is happening with the I.P.M. program, tree nutrition and post harvest handling) with some success but even these are hampered by a lack of background information. A lack of understanding of the pest complexes makes implementation of the I.P.M. more difficult as new pests are discovered and taking measures to improve tree yield is hampered when the current yield is not known. Thus much of the current research is about answering some basic questions in order to proceed from a sound base, i.e. a sound data base from as many sources as possible.
The other very important factor in the research base is the personnel involved. It is the skills of the staff involved which often determines the success of trials and attempted changes in production systems. This involves disciplinary competences of professional and support staff and, in a farming systems approach, goes further to include interdisciplinary co-operation, communication skills and a willingness to consider a wide range of views and possibilities. These skills are especially important in onfarm research where communication with estate staff and consideration of their problems/perspectives is essential. Development of such skills often takes time and must be actively sponsored by team leaders. Longer term training (such as university based) can be important and may be necessary in reaching disciplinary competence for future program leaders and researchers.

As for the above, the appropriate facilities and logistic/institutional support is necessary. The Malawian Government is limited in what it can provide. Mr R. Clough (World Bank representative for Malawi) has indicated the current World Bank funded development of research stations is nearing the end of its term and has lead to a substantial improvement in facilities. The main problems at present are the provision of transport for onfarm trials, the lack of computers for data analysis and the low level of funding for the necessary 'consumables' to help keep the support facilities running. The estate sector is providing support in this area and is increasing the level of support. It is difficult to predict where the future lies in this area. However, the interdisciplinary nature of the team and the recent initiatives by Government (e.g. World Bank funding proposal and smallholder
proposal to African Development Bank) and by growers (increasing the research and development levies) are very positive. A summary of problems and opportunities will be given later.

3) Planning onfarm research

Problems and opportunities arising in 2 form the basis for the research program. The potential for improvement (in the production system or a subsystem) becomes the basis for setting research objectives which can be short term and long term. Consideration of constraints (e.g. institutional support capacity), of alternative methodologies (e.g. researcher managed or super imposed trials, imported technology or development of local technology) and of alternative activities for researchers efforts (plant nutrition or irrigation) leads to finalising plans for research. It is unlikely that any one trial could come to grips with all the previous problems so a number of trials will be needed. These will be refined as more information is available as would be expected.

Formalising this stage would require a team effort to ensure maximum utilisation of resources. This is the case with macadamia where the datum trees used in entomology are also used by agronomy in a complementary manner and results are shared to the benefit of each. Planning is an ongoing activity as objectives are achieved or priorities change so the next two stages of the steps of Shanner are really part of a circular process involving planning, action and analysis leading to refinements in planning and so on. Research staff and resources are already heavily committed in Malawi so further
work can be planned but will not be implemented until completion of some current work allows. Long term planning of an onfarm research program is useful but flexibility is still required to meet changing circumstances.

4) Onfarm research and analysis

There are a number of trials being undertaken in this mode, in particular, the I.P.M. program, the tree size/yield relationships, the nutrition recommendations and the pesticide application trial. Further work is planned (such as clonal evaluation) and co-operation has been very good. With tree nuts, this approach has been used in the past and is generally different from the approach taken through the research system in Malawi. Normally, most of the work is research station based and the Agricultural Development Divisions have the extension role to smallholders. Macadamia is largely an estate crop and Agricultural Development Divisions tend not to be involved in this sector hence the dual role of research/extension agent for the macadamia team has evolved.

The main advantage of onfarm research is that it allows a large amount of management input into the work which allows researchers to get a greater understanding of management practices and responses. This information is very important in analysing the results and looking to likely acceptance of changes and management reactions which helps give direction for the future. Where management flexibility is limited in relation to inputs (such as labour, timeliness of operation, use of equipment) or some other factors, a measure of acceptability of likely changes and/or technologies can be
gained. Continued communication is also important in the process. Starting from a prediction of likely results and proceeding to actual findings with inputs from management, appropriate technology for the target group can be developed.

Analysis of results needs to consider biological, economic and other factors where necessary (e.g. health of workers or social benefits, wider implications of research work) to give as complete a picture as possible of the utility of the information obtained. Effective implementation of results of the program depend on this. Putting macadamia into context as part of the overall estate management is an important consideration here, e.g. would macadamia harvesting and drying compete for coffee harvesting and drying labour and facilities?

Although an emphasis is being placed on onfarm research, this does not exclude onstation work. A considerable amount of onstation work is also in progress, such as the breeding and rearing of bugs and parasites which give insights and information needed in onfarm research. Experimentation techniques need to be correct, analysis of results thorough and a sound data base needs to be established for comparisons.

5) Extension of results

As mentioned earlier, research and extension tend to go hand in hand in the approach. However, not all estates are included in trial work so the extension of results to all members of the target is necessary. Field days and seminars are used as well as direct visits. Training courses and manuals are also used (as in the nursery manual and training course and the pest management course and notes). When sufficient information is
available or where a perceived need arises, extension is arranged accordingly.

The smallholders present a challenge in this regard. Firstly, insufficient information exists about their situation. Secondly, the majority are located well away from the base of the researchers and finally, the Agricultural Development Divisions who usually serve this group have very little information on macadamia to work with. It is hoped the production and pest management manuals will help in this regard. However, improved information and technical bases will not necessarily help them in making an income from macadamia since there is no infrastructural support in handling the nut and delivery to the processor. The extent to which researchers and estate bodies such as the Tree Nut Growers Association can address these issues is limited. A much broader initiative from Government is needed and the approach to the African Development Bank is an indication of the willingness of Government in this regard.

The current research program in macadamia fit well with the farming systems approach, although not formally stated as such. The interdisciplinary nature of the team and the shared use of data and trial sites is very important and leads to better use of scarce resources. The onfarm nature of much of the work maintains the relevancy of the research and adds to the information base in a realistic useable way by considering the management views likely to effect the situation to be improved. Some of the work is at a stage where evaluation of the usefulness is possible (e.g. the nursery manual and supplementary irrigation investigation). The evaluation of
usefulness of information generated is not formally covered in either of the approaches given earlier. Evaluation is implied as an ongoing process which relies on the close contact between the researchers, extension agents and the target group. The liaison committee can provide a forum for debate in evaluating the usefulness and effectiveness of the information being generated. Reporting by researchers to the Tree Nut Growers Association and the Tree Nut Authority is important. Formalising an evaluation process is seen as important in the success of using a farming systems approach and of monitoring relevance in research work. An external review should also be undertaken periodically.

Estate Managers' Views

The simple industry model and the graphic representation of the kernel recovery function were presented to members of the liaison committee and others for comment with five questions. The questions were open ended and could have been answered to any depth according to the members views and feelings. The questions were as follows:

As Managers

1) What are your views and aspirations for the production systems for macadamia?

2) What are your aims and aspirations for the industry as a whole?

3) What do you see as the problems or areas for improvements in the production system?
4) To what extent are you prepared to make changes in order to achieve improvements?

5) What are the views of this committee as a forum for debate and dialogue regarding research, industry and management of estates?

The answers received varied in depth and content and are summarised as follows:

Q.1 - to be the largest producers with the highest possible quality kernels in Malawi.
- the company is listed on the London stock exchange so does have a profit motive but due to its present tea investment, all the better land is devoted to tea and shall continue to be so during development, the macadamia being regulated to secondary land with lower rainfall or a steeper topography, but managed to obtain maximum returns.
- macadamia will always be a diversification crop.
- macadamia is part of our diversification program and we will continue to recycle land such as tung land to macadamia as finances allow. It will only occupy a small percentage of land area.
- (of the model) that seems about right.
- we inherited (by buying a tea estate) a large area of macadamia and have to try to get some return on investment.
- to produce the highest yield possible of first grade macadamia kernels at the most economic cost.
Q2. - regarding the future of macadamia within Malawi, with the low labour cost and plentiful supply of labour, it must expand with the capital being spent on new clearings and the possibilities of new factories confirm this. However, as with the tea industry, most of the advances and innovations will come from the estate sector.

- as far as the industry is concerned, it is most important every encouragement be given to the smallholder section. Just five trees per family house producing good quality nuts would double the average Malawi family income.

- macadamia has a long pay-back period and large plantings are difficult to justify.

- the industry has a good future provided we can get our yield and quality right.

- the Malawian macadamia industry should, in addition to answer 1 above, ensure that it produces a product that is better than comparable products from elsewhere, and at the same time, keep abreast with developments and market trends so as to produce a macadamia that keeps it in the forefront of the world wide industry.

- the industry must not become static and thereby fall behind the standards of other producing countries.

Q.3 - when it comes to areas that need improvement, I think if growers set themselves the following objectives, most of the problems will have been solved:

a) Average yield of 40kg of nut in shell per tree at 10% moisture at 10 years and over.

b) Improved crack out to 30%+. 
c) Improved kernel recovery to 95% grade one.
- improvements from the company's point of view can be made in field management, i.e. employing better qualified field assistants and supervisors who can implement the more technical recommendations of the research team.
- getting our sound kernel recovery up to 30% is my main objective and getting better insect control.
- our aim is to get good trees in the ground and get the management right to start with and avoid all the existing problems as much as possible.
- we see many areas where improvements are required and we list them below
  a) the selection and growing of improved clones best suited to the Malawian climate
  b) improved nursery techniques
  c) a greater knowledge of the physiology of the macadamia leading to better agronomic techniques
  d) I.P. Management and disease management
  e) sprayers and spraying techniques
  f) nutrition
  g) harvesting methods
  h) improvement and innovations in post harvesting machinery and techniques
  i) better crop handling.

Q4. - we would be prepared to make any changes necessary that are economically viable.
- finance and head office limit what we can do.
finance for existing plantings is not restricted but during low profit years the capital for new macadamia plantings will be stopped to give preference to tea.

- I will do whatever I can to implement your recommendations.

- provided changes will achieve improved yields and better quality at a good economic return, they will be made.

Q.5 - the research committee should only be at this stage a liaison body between the growers and the researchers team.

- the role of our committee is to put out the findings and information on macadamia to all growers, not only those who are benefitting from your visits and attention. Unfortunately this is time consuming as far as your research is concerned but I do feel that a large proportion of the industry is not receiving all the information available. However, I trust that in the committee you will be able to get feedback from the growers in the way both the industry and attitudes are leading since from a small beginning macadamia planting is gaining momentum very fast.

- the committee should only make recommendations to the Tree Nut Growers Association about research matters.

- without debate and dialogue between research and the industry, little progress will be made. Management will become involved when decisions have to be finally taken, particularly those involving the economics of any operation, therefore the committee in its present form and with its current mandate probably gives the best opportunity for the debate and dialogue required. Open
sessions and field days for senior management will also contribute to this end.

On the answers and related discussions two interesting observations can be made. One is that only one manager commented on the production system model and second is that macadamia is a very small crop in the estate sense. The first could mean that the question and model concept was poorly communicated or that the managers are a long way removed from the actual production system. Both are factors but the type of management structure is important in implementation of changes because changing managers' ideas might be easy but transferring that to the hundreds of field staff may be difficult. The second point is also very important since macadamia has suffered in the past from ups and downs. Given that macadamia is a very small part of estate activities, its importance must also be well down the scale and commercial considerations will adversely affect the crop, even as part of a diversification program perhaps before or to a greater extent than the main crop.

Problems and Opportunities

The aim of this section is to list the major problems seen as priorities and what opportunities exist for overcoming these. These can be short and long term. Estates will vary in what is considered a problem depending on what stage they are at in the production system. Newly established plantings have different problems from producing plantings but all the problems are important in an overall context. Each subsystem in the simple
model used earlier will be looked at separately to give a clear picture.

1) Nursery Subsystem

Problem: Poor quality trees for field planting - small and poorly shaped with high loss rates at field plantings.

Causes: Lack of familiarity with macadamia requirements on a nursery crop on the part of the managers and staff, lack of propagation skills for macadamia, poor timing of plantings and cycling within the nursery, insufficient initial tree training in the nursery and insufficient culling of poor quality plants. Undue haste in trying to get plants from seed to field plants.

Opportunity: Generally overcome with more information and familiarity with the crop in the nursery sense, and by not rushing plantings unnecessarily. No real research required as information is available e.g. nursery manual and training course and from other estates but continued extension visits required. It is difficult to place a monetary value on this although a more efficient nursery and low field losses at planting would reduce establishment costs.

2) Field Operations

Problem: Insect damage, particularly piercing and sucking bugs and nut borers resulting in large losses in kernel in nuts delivered to the factory (46.2% of total losses recorded in 1988-89 season).

Causes: Lack of information about the pest complexes, inability to effectively spray trees caused by large tree size
and type of equipment used and also by the cropping system such as interplanting with coffee.

Opportunity: Information gathering takes time but is essential in overcoming the problem and providing the background for long term control measures such as biological control measures and the I.P.M. program. Improving spray efficiency can improve the effectiveness of existing measures (e.g. correct calibration to give effective application rates) and equipment but will not overcome the tree size problem. Current mature plantings (and most future plantings it seems) are on land which is not necessarily tractorable and the use of high volume air blast type sprayers (as used in Australia) is not often an option. Considerable investment in equipment is needed in many cases to improve the efficiency of existing measures (such as having enough mist blowers to get around all trees in a given period). Tree size and efficiency of application will remain a problem on mature plantings for some time to come. Aerial spraying offers a possibility and is being investigated as a way of improving effectiveness but is only likely to be part of a larger strategy. Biological controls offer the best long term opportunities as well as controlling tree size in existing and new plantings.

Biological control will be a long process leading on from the I.P.M. program and requires basic as well as applied research. Some assistance from outside of Malawi where similar work is being conducted would speed up the process. Controlling tree size (which will be discussed in detail later) falls into three categories - physical such as pruning; physiological such as
chemicals including Cultar (Ploctobutrazole) and nutrition especially nitrogen; and genetic such as dwarfing rootstocks and scion material. As far as insect control is concerned on existing large trees, physical control by pruning and physiological control by restricting growth offer considerable potential to reduce tree size. Tree height is the main limiting factor for the reach of small ground based applicators so controlling height will be useful in the short and longer term as well.

Improved insect control offers great potential to increase kernel recovery from existing production and much current work is aimed at addressing this. However, insect control on its own will not improve nut quality but would still improve returns by increasing the weight of potentially saleable kernel, recovered from nut in shell.

Problem: Fungal attack of flowers leading to large scale shedding of flowers and raceames without nut set.

Cause: Fungal Pathogen (Botritus sp and Cladosporium sp have been identified so far) infect the newly developing and open flower raceames (often in association with thrips and aphids) causing the flower to fall without pollination, thereby reducing potential nut set. Cool misty weather encourages the fungal attacks.

Opportunity: Not a lot is known about this complex but observations suggest it is a serious problem, especially at some sites. Effective control is likely using fungicides already available provided they are applied on time and with
sufficient coverage. Once again, application efficiency and tree size are major obstacles as discussed in insect damage. Field work is required to establish if there is a quantifiable relationship between fungal attack, nut set and yield, and also to test the efficacy of available fungicides for control. Timeliness of operation is particularly important due to the rapid spread of fungi under favourable conditions. Devising prediction models based on infection rates related to weather conditions is probably not realistic at this stage because of lack of information and equipment but is a long term goal worth considering. Those sites which appear to have a problem could use a preventative approach on large blocks and observe the effects over a few seasons (a superimposed type of trial) which should give enough information for future direction when added to the current pathology work.

Problem: Kernel quality is variable and tends towards a lower oil content than competitors. Similarly, kernel malformation and discolouring is a serious cause of factory losses from many estates and is now being separated out in the factory. Grade 3 (i.e. kernel with less than 65% oil content and not saleable using the Malawi system) accounted for 27.9% of total losses at the factory in 1988-89. Figures are not available for separate discolouration and malformation.

Causes: The main cause is the nutritional management of the crop especially the nitrogen/potassium balance and micronutrients such as boron. Other factors relate to ability of the tree to uptake nutrients and efficiency of the tree in this environment.
Opportunities: Major gains can be made relatively quickly by changing fertiliser usage, by improving the information available and updating recommendations and monitoring the effects on nut quality problems. This plus diagnostic tools such as leaf analysis should be able to guide the improvements which will end up being refined to individual sites. Difficulties arise where macadamia are interplanted with coffee which has a much higher nutrition plane than macadamia and where the trees have been neglected for long periods and/or where erosion/continual hoeing has affected the root system. Mulching with organic matter is needed to rebuild the root system. Very detailed work on the environment/tree production relationship is beyond the resources of the researchers although work of this type is planned in the northern region by the Commonwealth Development Corporation. Similar work is being undertaken in Australia.

Simply improving nutrition will lead to improved returns for, in many cases, less expenditure on inputs. This should be done in conjunction with improved husbandry practices such as mulching to get the long term benefits. No real research is needed, except for perhaps potassium and sulphur as appropriate leaf levels have been set elsewhere which are broadly applicable in Malawi. Monitoring changes and making adjustments and refinements is seen as a more relevant researchers role.

Problem: Low yield of nut in shall at a number of sites.

Cause: Probably overall management including nutrition except on sites which could be considered at the edge of the trees
climatic range (possibly the northern areas and low/dry areas). Limited clonal adaption is also a factor.

Opportunities: Improving information available to the industry in general in order to improve the level of management in the field should improve the situation. Changes can be monitored by the researchers. The production manual is seen as a useful way of overcoming this problem although it will take some time for results to show. The tree size/yield relationship is providing basic data for comparisons in the monitoring process. The effectiveness of recommendations made in the manual can be gauged in this way. Unless a particular yield limiting factor is identified from other work, no research is warranted at this stage because there is nothing in particular to research. The phenological cycling (and resulting flowering/cropping patterns) may give some clues in the future but the biggest gain will come from known information utilised on farm.

Problem: Trees are generally larger in Malawi than say, Australia, without a corresponding increase in yield.

Cause: A number of possible causes but most likely related to favourable growing conditions, especially nutrition and climate which favour vegetative growth over fruiting ability. Can be natural fertility or induced from applied nutrients so it may be not completely avoidable.

Opportunities: There are three ways of controlling tree size. Physically by pruning; physiologically by manipulation of the tree physiology such as the use of plant growth regulators or limiting nutrition; and by genetic means such as smaller stature clones or dwarfing characteristics of rootstock. All
these approaches have potential, the latter being long term but also the most permanent. Since tree size is presenting problems for insect and disease control which are unlikely to be overcome with a straightforward technological approach this problem is worthy of considerable research input. In the short term, pruning of large trees is a worthwhile start and the use of labour is not a problem in general terms. Balancing nutrition in favour of fruiting by reducing nitrogen levels and having a more balanced nutrition program will help 'hold' trees, especially if heavier cropping is induced in the process. Some pruning has been done in Malawi and overseas and this information should be utilised in establishing onfarm research. One complication is where trees have been pruned up from the ground a few metres (because of a coffee intercropping or to avoid theft) which limits the amount of top down pruning possible.

The use of plant growth regulator as in the Cultar trial is unlikely to be of much benefit on large trees unless used in conjunction with pruning to bring the trees into the desired range. Used in this context, plant growth regulators could be useful but, as industry experience has demonstrated, they are a long way from commercial use. On younger trees, they may have more application but are also not a short term option. The cost is a factor and the current trials will give some indication of the value on young trees.

Balancing nutrition on young trees and encouraging early fruiting usually helps in controlling tree size but if natural fertility is reasonably high, this approach may not work very well. This leaves genetics as the most viable long term
option, including the exploration of clonal material where tree size is a consideration and investigation of possible dwarfing potential existing in Malawi. The dwarfing work would involve a fairly detailed long term study requiring a high level of commitment and continuity and as such, probably warrants a separate program. This is unlikely in the current Malawi context. However, controlling tree size is necessary in improving productivity and will give the industry better returns.

Problem: Present clones are not performing as well as they could (or do elsewhere) and this is limiting yields.

Cause: Clonal material used in Malawi was imported from outside, not selected locally, and performance is not as good as it could be.

Opportunities: There are two ways of overcoming this problem. One is the current approach of importing more clonal material and hoping it will perform well; the second is to start with the seed of known good parents and select from these based on strict selection criteria. The first approach means that the nut quality will probably be good with reasonable management and hence nuts produced will be suitable for processing. Yield and adaption are still unknowns. The second approach offers the greatest chance of getting all three in much the same time frame but occupies more land and takes more research time. The existing seedling block at Bvumbwe Agricultural Research Station is an example of the benefits of the later approach with a few trees showing promise from the large number planted. Considerable long term benefits would result from locally
adapted, superior clonal material and this is a long term research need.

3) Post-harvest Subsystem

Problem: Cracked nuts with unusable kernel (rancid/discoloured and mouldy) attributed largely to post harvest problems.

Cause: Shell damage occurring during dehusking and onfarm drying/storage of nuts.

Opportunity: The information and technology is available to overcome this problem. Improved dehusking machines are available and have been imported so this information should spread fairly quickly throughout the industry. This will reduce the damage occurring to shells during dehusking and improve the efficiency of the subsystem. Utilising the correct steps in drying, in particular avoiding heat in the first few days, is important in reducing shell cracking and damage to kernel. This problem should be largely overcome in a couple of seasons on estates and no research is required, but the necessary information needs to be made available, including sharing technology between estates. However, the smallholders could present a problem and this needs to be considered. Onfarm storage will become more important as production increases because the factory has limited storage and drying capacity and is unlikely to be able to cope with the volume expected in years to come.
4) Management Subsystem

Problem: Lack of information in many areas including agronomy, pests, disease control economics, post harvest handling and a coherent management plan.

Cause: Probably low status of the crop until recently and the general limited amount of information available on macadamia worldwide.

Opportunity: Updating and expanding the information base is a need for researchers as well as managers and is being addressed in current work through written material and extension visits. The manuals should provide a useful guide. However, it must be noted that appropriate information needs to generated to make it worth disseminating so many of the current recommendations will need refining. Keeping abreast of the industry in other countries is worthwhile. Having a formalised data base system as discussed in the Technical Liaison Committee meetings would be useful.

Problem: Management flexibility in what they can do to their situations.

Cause: Managers are under time constraints, physical constraints, financial limits and are operating in a dynamic situation, hence all that is desirable is not possible.

Opportunity: This is up to the individual. Getting the best return from existing plantings within the constraints of the individual situation is one way of expressing the opportunity. Researchers have a role in providing information and options
which the manager will refine to suit his situation. With a profit motive, increasing profit from existing planting will encourage effort in that area and allocation of resources is easier if returns are good. Since the majority of the crop is exported, world prices and markets will be very important. Although this aspect is outside of the research area, its influences will be felt.

5) Research and Extension Subsystem

Problem: Constraints relating to existing infrastructure and resources.

Cause: Funds are limited for virtually all activities of the research team. Existing infrastructure and institutions have limitations.

Opportunity: Scarce resources should force the researchers to use the funds as efficiently as possible. Shared trial sites and interdisciplinary co-operation are being used at the moment. The less intensive super-imposed approach to agronomy trials such as the nutrition recommendations is another. Prioritising work becomes essential but usually encourages a short term focus.

The existing research system in Malawi imposes constraints on the research team although some of these are being circumnavigated at the moment with the use of the estate vehicle for entomology and so on. The interdisciplinary team is very important and a vocal target group with their own resources helps. However, part of the flexibility existing at present is because of the Australian staffing input and the
Malawian staff may feel more restricted because of their long term obligations to the Government system. Gaining understanding and acceptance of a true co-operative interdisciplinary approach would help overcome some of these problems. Taking a broader view more like a farming system approach is another way of encouraging staff to work with the constraints. The short term input of Australian staff (2-4 years) is not enough time to really develop a farming system research program. This paper is more about utilising a farming system approach to setting priorities and acknowledging the broader situation and encouraging counterparts to look at their work differently, within the existing structure. Trying to change the structures from within is not likely to be viable without a top down change and considerable financial input.

6) Formal and Informal Regulation Subsystem

Problem: Regulation and management of the industry in general.

Cause: No cause required, just existing status quo.

Opportunity: The Tree Nut Authority and Tree Nut Growers Association are the formal and informal regulating bodies respectively in the industry at present. Both these bodies have considerable power and are forums for debate on a wide range of issues. The levies for research are raised through these for example. Having strong industry bodies is an asset to the industry and continued industry participation is important. The Technical Liaison Committee is a very positive step for effective research. Critique of the research program will come from the committee and directions for the future as well.
These problems and opportunities are by no means exhaustive but present a general view of the industry at present. They will change with time as the situation changes. Priorities will be different in 10 years time and this should be reflected in the research.

Some Difficulties with Using a Farming Systems Approach

There are some issues which need to be discussed in relation to using a farming systems approach in macadamia research. These include the use of this approach in a corporate estate structure (a hybrid type of farming activity compared to farming families, the usual domain of farming system work); flexibility versus constraint breaking; the likely effectiveness and sustainability of this approach; confusion as to who the target is (estates, smallholders, researchers, the research system) and, why bother anyway.

The traditional estate sector where most macadamia are grown are usually part of large corporate structures, often public companies, which have obligations and values different to the small farmers who are the usual target of farming systems approaches in developing nations. There is a clear profit motive for example and obligations to shareholders. They have no direct parallel with most developed nations farmers and are more like the middle level service oriented agribusiness that exists in Australia and the United Kingdom in the manner in which they operate, except that there is a high level of integration from production to processing. They are a hybrid type of producer with corporate structures similar to developed nations but farming practices more closely related to
smallholders. As a target group, they are reasonably similar and at this stage, small in number and communication is not difficult for those involved in the research. The profit motive means that aims and outcomes are usually expressed in monetary terms. Managers can readily express their aims and constraints in relation to onfarm activities and have reasonably stable production systems based on longer term crops such as tea and coffee and macadamia. Making radical changes to the production system is not viable in the short term and examining the socio-economic aspects of estates in the broader context is not relevant given the Government's stated development aims as outlined earlier. This leaves the relevance of the approach in two areas - one is to give direction to future research by the use of more academic exercises such as modelling and the other being the onfarm research with a farming system perspective to tackle immediate problems. Simmonds (1984) gave these as two of the types of farming systems research, the other the more radical "new farming systems" which advocates major changes to existing systems or the development of new production systems. The approach is valid provided some short comings are noted - the need for the commodity team to be truly interdisciplinary in approach and the need for the commodity to be sufficiently important to the target group so that research into the commodity will not be overshadowed by priorities being placed elsewhere in the overall estate production systems, e.g. on tea or coffee. This fits with what Norman and Collinson (1985) describe as farming systems research with a predetermined focus (i.e. using existing commodity teams).
The breaking of constraints as opposed to exploiting flexibilities within the production system is worth discussing. Focusing of research is related to the above and long term strategies versus short term strategies is important. With macadamia in Malawi, exploiting the flexibilities in the production system will lead to rapid gains. For example, improving spray application or improved nutritional management are areas where flexibility exists and rapid changes can be made and the improvements monitored. Much of the current research is directed towards this approach. However, this really only leads to getting better performance or realising the potential of the existing system. Breaking constraints in the existing system, giving a new potential, is more difficult but leads to long term gains beyond the current potential. Examples are selecting high yielding, high quality locally adapted clones superior to existing clones and developing biological control measures for but control which reduces the usages for chemicals. Another is developing a dwarfing rootstock which could completely change the production systems in the future. Some balance needs to be found between these two aspects in research because, although they are complementary in a development sense, they are competative for available resources. Using the farming system approach with problems and opportunities and managers views can provide a short and longer term view as well as covering the immediate problems.

The questions could be asked as to how sustainable this approach is. The Australian input is short term and will not 'solve' all the current problems but should lead to some improvements. The improvements need not all be in the onfarm
production system and improving the skills and confidence of Malawian researchers is very important. Having a research focus and direction is fine but the Malawians are the people who will have to see this through. Broadening their approach and introducing a more systematic way of looking at research beyond the technical aspects is useful in monitoring the relevance of research and having a framework to operate in makes this easier to achieve. Getting the Commodity Team working as a team is important in achieving results. Using a farming systems program is not the aim or even remotely possible but encouraging thought and ideas and discussion among researchers and managers is achievable and sustainable. Estates have a large role to play in this process as well by monitoring the linkages between the managers and researchers from their end. With the small team and small industry, an interdisciplinary Commodity Team and the desire, surely improvements can be gained.
5. OUTCOMES OF THE PROJECT

The core project of day to day research, extension and official duties produced results. An analysis of factory deliveries for the 1990-91 season compared to the 1988-89 season showed considerable improvements in the quality of nuts delivered. This had arisen from changes in the production systems used on estates. In summary, the results (on an industry wide basis) were as follows:

As a proportion of sound kernel recovered, grade 1 has increased from 74.5% to 85.8%; grade 2 has reduced from 14.3% to 9.7% and grade 3 has reduced from 11.2% to 4.5%. Overall losses have fallen from 30% of total kernel recovered to 21.5% of kernel recovered. Total yield has increased slightly.

Although there is room for improvement, the figures represent an economic benefit to growers because grade 1 is the highest value kernel. Further refinements should continue the improvement trend although gains will become harder to obtain and seasonal variations will occur.

World Bank funding was received in May 1991 and arrangements were in place by the end of the author's contract for the funds to be used effectively. It is ironic that much of the work outlined in the funding proposal had been completed before the funds were received. However the research team and returning Malawian agronomist will get the benefit of the funds. The growers were now locked into formal funding arrangements and a precedent had been set for future external and internal
funding. The T.N.G.A. was also accumulating a pool of research funds which could be used in the future.

The Malawian co-researchers had been exposed to a different method of operation and a different philosophy to research and problem solving. A large amount of information had been injected into the system for the Malawians as well as the growers. The work being done had been approved through the project meeting system of the D.A.R. although there was resistance to change in some quarters. The above factors would also fulfil some of the aims of the A.S.A.S. scheme, i.e. of training and information transfer, although a true counterpart did not exist. A number of papers were written for local publication and some of the trial work will be re-written for publication elsewhere. A much clearer picture of macadamia growing in Malawi was now available.

Hence, the core project was satisfactorily completed except that time was not available to complete all the tasks outlined in the industry paper. Trying to separate the day to day requirements of the position from the desire to achieve something further for the thesis project was often awkward. The two were closely linked and the outcomes complementary. The main outcomes of the thesis project were the industry review paper, the successful re-instatement of the Technical Liaison Committee, the development of future research plans for macadamia and breaking down some of the barriers such as the factory secretiveness.

The industry review paper put the whole project in perspective, setting out the thoughts and ideas of the work. It brought all the parties into the process, especially estate managers, which
is necessary to gain wider acceptance of the broader issues. The paper generated discussion and focussed attention on the needs of the industry. The T.N.G.A. agreed that the paper did present an accurate assessment of the situation and did provide a sound basis for current and future research needs. The industry had a set of ideas and an improving information base to work with which had been lacking in the past. Industry-wide problems were now discussed as well as estate-based problems. The overall reaction by the industry was very favourable.

The Technical Liaison Committee provided a vehicle to formalise linkages between researchers and managers as well as reach all sections of the T.N.G.A. The Committee changed the 'them and us' attitudes to just 'us'. It was through this Committee that the issue of future research needs were presented to the industry. A meeting was held which resulted in the author writing a short paper on the future research needs, a synthesis of current work, perceived problems and future directions which would carry on from the current sound base that had been built. Appendix 1 contains a copy of this paper.

The publication of the Macadamia Reference Manual was a rounding off exercise by the author. This evolved from the Production and Pest Management Manual outlined in the review paper. It was written by the author with the assistance and involvement of others in the research team, reviewed by the Technical Liaison Committee, with the printing costs met by the T.N.G.A. and published under the authority of the T.N.A. It represented the first book of its kind on macadamia, combining the available information from literature, local knowledge and
research findings into one publication for Malawi. Appendix 2 contains the outline and contents page of the book.

Perhaps the most pleasing of the outcomes was the breaking down of barriers and improvement in relations with the industry. This is not all attributed to the author but he acted as a catalyst to make changes. For example, throughout the contract period, the 'factory' was an emotive issue and confrontations occurred over factory issues such as the secretiveness of the management and lack of marketing information. However, towards the end of the contract important changes occurred. The factory recording sheet and procedures were improved, making it easier for people to understand. Regular marketing reports were given to the T.N.G.A. meetings. The management of N.T.E. agreed that an Australian expert on factory management and macadamia processing be brought in to improve factory procedures. This will be paid for from the research pool set up as part of the growers' contribution to the World Bank funds. These are the type of changes which will bring long term benefits to the macadamia industry and researchers in Malawi.

Finally, utilising the work place as a study place forces the person to reflect upon and consider their actions in a way they may not do normally. This is one of the benefits of an action research project, allowing the person to learn from the experience for future benefit, formalising that process.
6. **DISCUSSION**

The farming system approach provided a useful way to express the need for change and provide a backdrop for a situation analysis. However, the outcomes are well short of a farming system research study in terms of socio-economic factors. The socio-economic aspects of estates is a highly political issue since the Life President and senior politicians are large estate owners (e.g. the Life President is the largest single tobacco farmer, tobacco being Malawi's major export earner). In discussions with Mr D. Newton, the Macadamia Manager at N.T.E., he expressed the feeling that in his 25 years of experience on estates in Malawi, little had changed with independence, and in recent years, the Malawians were worse off. The power issue is important and there is very little in the current work which will change the life of a Malawian labourer on an estate.

How appropriate are F.S.R. techniques to plantation or estate farming? This is an interesting question because the client group can clearly articulate aims and objectives. The steps set out to follow become rigid and restrictive if followed to the letter. The institutional constraints on government research personnel are severe and when such a small team (principally one person) is involved, the limits of what can be achieved are obvious. The estates as a whole would present an interesting F.S.R. study if the broader socio-economic issues were considered. Macadamia are a very small part of an estate farming system in Malawi so defining boundaries within the system is difficult. Competition between activities within estates present major problems for
managers and hence researchers. Similarly, the history behind and the nature of estate type production systems which aim to exploit comparative advantage for an export market coupled with in-country political support make value judgements about the estate sector difficult. However, an enormous difference exists between the managers and the labourers in income and lifestyle which would not be nearly as pronounced in a developed country whose consumers are the main beneficiaries of the labourers' efforts. This is an emotive issue beyond the scope of this thesis but it was also an issue which caused considerable personal concern and generated much discussion among the Malawian colleagues. Considerable resentment of estates and estate practices exist (including estates owned by wealthy Malawians). Given the type of politics in Malawi, the future stability of the nation and the future of estates must be in question.

Brouwer and Jansen (1989) give an extensive critique of farming systems research, pointing to the 'hard systems' concentration of real research effort. By this they mean the concentration on the production system and productivity. The same criticism could be levelled at this work but some points need to be made in its defence. Firstly, a full farming systems research project was not intended as this clearly could not be done under the circumstances. Secondly, a farming systems 'approach' was used in a broad sense (but admittedly still aimed at production) to broaden the thinking of the industry and get relevance in research. Thirdly, the estate sector does not fit into a smallholder category so investigating equity and allocation of resources was not relevant given the prevailing political situation.
There were no examples found to follow nor the time or competence to pursue this side. Finally, the job description and expectations were limiting and had a bias towards productivity. The needs of the employer and target group are important.

Bysouth (1985) expressed the view that farming systems research which was not associated with the development of the people would not really address the issues fully. Gall (1990) in a study of developing countries counted human development as the most important issue. Malawi rated 14th lowest in the world in the human development index, 7th lowest in the gross national product per capita. Clearly, this country has serious problems which this work does not pretend to address.

However, influence was exercised in the situation and the methodologies used could be justified on that basis. Two broad ideas of farming systems were used to affect the production system and information base and also broader policy issues through thinking about research and management. The issue of power was continually present and this backs up the value of an appreciative system perspective as outlined by Holt and Schoorl (1989). There was a very strong influence to maintain the status quo and existing power bases. This can be expressed in a comment by N.T.E.'s Chairman, (Mr C. Barrow), at a T.N.G.A. meeting in 1990. The meetings were normally held in the N.T.E. boardroom on Saturday mornings. The Chairman of the T.N.G.A. suggested that future meetings should be held on Fridays at the Thyolo Club (a more spacious, neutral venue).
Mr Barrow objected strongly concluding with "it's a brave man that changes 15 years of tradition." The meetings were changed to Friday but still held at N.T.E. Another interesting change occurred during 1990 with regard to the General Manager (Mr D. Emmott) for N.T.E. and his wife, the factory manager. Emmott is the Chairman of the Technical Liaison Technical Committee and was adamant about the boundaries of this Committee stopping at the factory door. This power largely came from his position at N.T.E. During the year (August) he was displaced from his position at N.T.E. by the Chairman's son and his wife 'retired' from the factory. Considerable disquiet existed in the industry about factory related matters. The presentation of the industry paper to the committee members and others outside the committee generated much discussion. At the next meeting, Emmott called a two hour informal discussion session prior to the meeting to discuss the boundaries, factory problems and information flows; this was a sizeable change of attitude.

Also on the matter of power, an informal group of growers held a meeting to discuss factory issues and apparent secrecy or lack of information coming from the factory. The N.T.E. Chairman heard about this meeting and made formal complaints about the managers to their respective company directors, claiming they were 'ganging up on N.T.E.' and had formed a 'gang of four' against the factory. A meeting finally resulted from the above between the N.T.E. management and growers where a number of points were cleared up and some changes agreed to. Some of the barriers were coming down and other problems such as the sampling
techniques, assessment criteria and recording/reporting sheets were being steadily overcome.

Does the project fulfil the criteria of a successful action research project: Bawden and Macadam (1988) listed four outcomes for that aim to be satisfied as outlined earlier. The researcher has a better idea of what action research is and how to apply the theories. The situation has improved and others involved in the situation, co-workers and clients, are better informed than before. It is pleasing to see a greater degree of openness, a willingness to debate constructively and will to act and learn from the outcomes.

However, some reflections on the methodology used are relevant. The ad hoc farming systems approach (Birgegard et al 1987) provided a background to work within because of the general lack of information available about the farming system used and the situation. The situation analysis fits into the first three steps of F.S.R. as outlined by Shanner et al (1982). Similarly, much of the day to day work involving the extension of information and ideas as well as implementing these passed through all five steps but the level of on farm research and analysis was more practical and common sense than scientific. Sometimes information from elsewhere was used as Norman and Baker (1986) described or, improvements were conceived, tested and implemented based on observations and discussions on the spot. Post harvest handling was an area where both the above were used to blend the techniques developed elsewhere into the local situation. Hence, the importance of the adaptive nature of F.S.R. in consultation with the target group, provided that
approach is flexible and the user does not try to follow steps doggedly.

The situation analysis and the field, onfarm orientation of F.S.R. allows for the flow of information on more difficult technical problems back to the research team. Although the research team in this case is very small, some changing of roles does take place between the extensionist F.S.R. and technical component scientist. An example is the physiological disorders occurring in nuts. The problem was first identified in the field on samples taken from the tree and cracked in situ. A broader survey indicated a widespread but irregular occurrence. The factory had not delineated the problem from others and was not aware of the disorder as a problem and hence did not look specifically for it. Changes were made in assessment procedures to accommodate the disorder, and information was gathered. Nutrition of the tree was a possible causal factor and some changes in fertiliser practices were made (which were happening anyway from other field observations). However, to be able to say with certainty what the cause of the disorder is, a separate research program conducted by a competent person in that field would need to be conducted. This highlights the importance of the linkages of F.S.R. to technical component research as outlined by Norman and Collinson (1985).

The above example also emphasises the importance of the multidisciplinary nature of F.S.R. and the importance of the technical competence of the staff. One of the serious problems facing the author was simply that, as an individual
with strengths and weaknesses, he could not cover all aspects of the situation to a depth that an area specialist could. It points to areas where further skills need to be developed or others with the skills need to be brought in, as happened with the factory specialist at the end of the author's involvement. However, the ability to bring others in was very limited so the next best approach was to develop an information base which would help in skill development for the author, team members and the industry in general.

Remenyi and Coxhead (1985) point to the difficulty caused by the long term nature of F.S.R. but the short term nature of typical Australian aid. This again raises the question of the effectiveness of F.S.R. in such circumstances. They feel that the approach can be used effectively, if in a limited way, to tackle particular problem areas in an aid setting. The position advertised did not call for a specialist in any particular field so the problem areas were not clearly defined at the start. The evolving role is more in line with setting up a research plan rather than conducting specific trials. Similarly, the effectiveness of short term intervention could be seen as having a dual focus - making immediate improvements in the situation (e.g. nutrition, post-harvest handling) and defining areas where longer term improvements can be made through a research plan (although not necessarily conducted by the same individual). The use of a farming systems approach in this way provides a conceptual framework to work within and can also be communicated to others fairly easily.
The Technical Liaison Committee emphasises the human element in this situation, as does the continual contact with field workers and occasionally smallholders. Drawing these people into the technology generation process is necessary for it to succeed. Making use of the knowledge these groups have is very important. An example of this is in clonal selection. Clone 333 has a thickish shell and a lower kernel recovery than some other clones and was no longer a recommended clone. Discussions with farmers and smallholders as well as field observations indicated the tree's hardiness and ability to do well under adverse conditions. Further studies (including the tree size/yield data) indicated the suitability of the clone for smallholders and in difficult situations on estates where its performance exceeded others with minimal inputs. Armed with this information, it was possible to re-instate 333 as an acceptable clone through the Technical Liaison Committee, despite objections from the factory and Committee Chairman.

In discussions with co-workers on the methods used and approach taken, Mr J.W. Ching'ani, (Senior Technical Assistant) considered the methodology "more practical than academic". He contrasted this to the work of Professor Allan from the Republic of South Africa (Professor Allan is a plant physiologist formerly from the University of Natal). Professor Allan wrote two, quite detailed reports in 1986 and 1987, on certain aspects of the industry which had minimal impact, probably because there was little follow through in implementing the ideas and also the impractical nature of some suggestions. Tree misting to reduce leaf temperature is a good example. This is a valid research
technique for specific purposes but impractical in large orchards in Malawi. However, the practical day to day techniques cannot tackle every problem encountered, especially those for which no information or possible improvement are available. Similarly, the practical input reflects the work pressure in this area and also the orientation of the author's background and biases to some extent. More is needed - hence the development of a research plan in the second year to address problems not readily solvable in the short term.

Holt and Schoorl (1989) point to the lack of papers written covering methodology used by agricultural practitioners. They make the comment that those involved in the field tend to be most concerned with the 'doing' than formulation of theories or evaluating methodologies. They point to the need for more critical input in this area and give a cosmology for putting ideas into practice involving appreciative systems, soft systems and hard systems.

The farming system approach can accommodate hard systems easily and soft systems to some extent, but appreciative systems less so due to the way in projects they tend to be set up. This is because of the external orientation of the ideas for the farmer rather than with the farmer, implying someone else's appreciation rather than the farmers. The situation with clone 333 also demonstrates this problem - the factory managers decided they did not like 333 for processing reasons and sought to superimpose their 'appreciation' upon the rest of the industry despite some estates and smallholders favouring the clone for their own
reasons. In tackling such situations, some degree of risk is involved, conflict being likely, so it becomes difficult to put forward a methodology which actually encourages conflict and risk and get people to use it.

Action research does try to come to grips with conflict through active involvement in the situation which then changes the situation, and the researcher's attitudes as well, in the process. This goes beyond the practicalities into the techniques used as well through reflection upon the outcomes. Action research can provide a framework to consider criticisms of the methods used. This results from using the method and then reflecting upon and trying to improve upon the methods. Shortcomings thus revealed can be tackled in methodology and the operators skills to be utilised in the next phase or project. Both farming systems approaches and action research involve some degree of reflection and risk. The presentation of the industry paper involved some degree of risk but also contained a degree of reflection necessary to encourage change in the situation. One of the most important aspects of the reflection process was to highlight those shortcomings (of the author) which require further learning and skills development.

However, conducting sound trials does not necessarily lead to improvements. The entomologist in the research team conducted a large 'result demonstration trial' as the focus of his work. This was the method he felt was the best way to convince the industry to change the way it managed pests. The trial consisted of a large scale pest monitoring program with important decisions, such as when to apply chemicals,
made by the researcher. The entomologist was having difficulty in getting estates to cooperate fully despite two years of work. Part of the problem seemed to stem from the lack of involvement of managers in the research - they had little understanding of the work and viewed the research more as a free pest monitoring service than research. The result demonstration trial failed to address fundamental issues such as spray application methods, central to pest control, or estate purchasing methods which limit chemical availability. Failure to consider broader issues or more of the systems involved reduced the effectiveness of the input despite the best intentions and dedication to duty. Any one methodology cannot cope with all situations so a multi-disciplinary/multi-method approach is required with individuals of complementary skills.

In theory, this is the nature of a farming systems approach although much of the work in the first year concentrated on the hard systems while preparing the way for the further integration of soft systems and appreciative systems into the second year. The emphasis was then more academic and sought to formalise the wider participation of all those involved. Hence, it concentrated on the development of an information base (to give participants more information and power in decision making) and the development of a research plan to carry the industry into the future (using an open forum of participants).

It is important to consider the amount of communication involved with participatory research approaches because effective communication is a major factor in the amount of
influence a person can have. This was demonstrated by the meeting to discuss future research where estates not involved with entomology's result demonstration trials felt they were not part of the research and were not receiving much benefit. There are definite limits to the amount of effective communication a person can have with a given size of client group, especially where the majority must be done on a one to one or one to a small group basis. This would be a problem with the top down approach or F.S.R. in circumstances where a large target group is to be covered. In reality, it brings into question much of the aid work undertaken, because it would take large numbers of people working with small groups to affect change in rural areas across a broad front. Whilst this is a simplification of the situation it should not be overlooked by people undertaking projects of this kind. It is very easy to alienate people who should be involved because of a lack of communication. Some aspects of this project would have been improved with increased communication skills.

An action research project in this setting presents some problems but also some advantages. The problems are involved with the need to operate on a number of different levels concurrently within the situation; the conflicts which arise and dualisms involved, and the shortcomings of the researcher involved. The latter point is also one of the advantages in a learning sense; the need for active participation and a high level of motivation are other advantages. This project fits into the general description of action research given by Foster (1972) and covers at least the first two types of action research given by Grundy
(1987). The second year tended to cover more of an emancipatory category since the longer term involvement will facilitate this end.

The problems first - the need to operate on different levels is part of trying to take a broad approach. Hence, day to day concerns need to be seen in the light of longer term concerns; the individual farmer with a few trees, to an estate with 500 hectares, to the industry, to the national concerns. Trying to balance these without losing sight of the action researcher's other concerns - learning from the situation, changing the situation, achieving education goals - is difficult. The day to day realities can be overwhelming. The client groups are not necessarily interested in the action researcher's own objectives - it is not their concern if the researcher gets a degree or not, they have their own concerns. To take 'time out' to reflect may not be easy. To try to implement a change perceived to be unnecessary or undesired (particularly if the 'power' issues are not obvious or well considered) by some groups could have serious consequences for the researcher. To have a 'falling out' with the client group would render the situation hostile and of little use. Hence, there are personal risks involved which the researcher must by wary of.

When attempting to implement a broad approach and by delving into unfamiliar areas the researcher's limitations such as lack of knowledge, biases and lack of skills, become obvious. This is a problem when time is not available to correct the problems or where the researcher is not prepared
to confront his shortcomings such as biases. In coming to grips with some of the problems encountered in the field, the work of Spedding (1988) has been invaluable and also Zandstra (1977) and Harwood (1983). Utilising the work of others is very important.

Confronting biases can be difficult. An example is irrigation trials. The author did not really want to conduct irrigation trials for a variety of reasons, partly personal bias. A compromise was reached which resulted in the background information being clarified by the research team. Then, one keen manager initiated his own trial with the assistance of the author and others, the results of which would be analysed by the research team. Day to day management was the manager's responsibility with the outcomes available to all through the research team - a shared responsibility.

Attempting to improve the researcher's skills as a researcher and as a practitioner in the field are two of the outcomes for an action research program given by Bawden and Madadam (1988). Improving skills has been an important outcome for the researcher in this situation. It has been necessary to collect, assess and interpret large amounts of information and integrate this towards situation improvements. Often, considerable justification was required to initiate an improvement. Considerable improvements in the situation are occurring, both in the knowledge base and in the field leading to higher kernel recoveries and better quality nuts. The farming systems paper was presented to the industry to improve the
understanding of others involved in the situation as well as the researcher's own understanding.

Trying to write an action research thesis has not been easy because of the overlap between the concerns of various parties involved which influence the situation. The evolving nature of the work is different from a set research task common to Technical Component Research although many of the outcomes of the project will lead to Technical Component Research. Perry and Zuber-Skerritt's (1990) idea of two projects in one has been attempted here. Each step of the project has an influence on the other and all are subject to other influences such as external factors. Time is a limiting factor for the action research thesis in this setting because of continual day to day work pressure. The active participation approach requires a high degree of motivation and involves risk. Thus, it would not suit some personalities or some situations. It does provide a conceptual framework to work within and allows skill development through reflection on learning by doing. It is complementary to other forms of research such as technical or scientific, mobilising information and action into outcomes in a broader setting.
APPENDICES
Future Research Needs for Macadamia and Cashew Nuts in Malawi
FUTURE RESEARCH NEEDS FOR MACADAMIA AND CASHEW NUTS IN MALAWI

The macadamia and cashew nut industries have made considerable improvements in recent years. The macadamia industry is much further advanced than the cashew industry and receives the majority of research and extension effort. The location of the Tree Nut Commodity at Bvumbwe Agricultural Research Station close to the major southern macadamia growing areas has assisted macadamia rather than cashew. Both crops have problems which are limiting in various aspect of culture. The Tree Nut Commodity (in conjunction with the industry) can help overcome some of these. The purpose of this paper is to suggest areas where future research can have a significant impact to ensure the viability of the tree nut crops.

In order to define areas where problems exist and improvements may be achieved, discussions with industry were initiated on 30th May 1991 (macadamia) and 3rd June (cashew) to facilitate this process. The suggestions will be balanced against restrictions on research resources.

Macadamia

A growers' forum was held to give growers the chance to put forward ideas and outline what they consider to be the major problem areas where future research could have an impact. An outline of current work was given and persons in attendance were asked to write down these thoughts on the paper provided. These were collected, collated and a list for discussion prepared to put to the meeting. A number of issues were raised which were not strictly research but were still valid comment. These included critique of current programs and extension efforts; processing and marketing problems as well as problems occurring in the field which are primarily extension related not requiring research effort. The need for more training programs in various areas was raised. The above comments have been noted by the research team and some adjustments to current programs are being made to accommodate these.

The comments also highlight some problems the research team have in balancing extension and research efforts. Much of the comment received concentrated on the extension effort and day to day field problems rather than research per se. Although this reflects the concerns of those present it may not reflect longer term research needs. Also important was the need to get the most from existing plantings - this is a high priority for most estates with large plantings of existing trees who may or may not have plans for further plantings. A number of areas involved with orchard management were highlighted including insect and disease control, spray application technology; nutrition management; tree pruning, spacing and size control; yield and quality improvement; irrigation and sustainable production techniques.
Current research and extension efforts have been addressing some of the problems raised. The focus of the agronomy program has been to define the situation, put in place monitoring systems, update the information base, improve obvious problem areas and carry on existing trials deemed worthwhile. A large part of this work has been completed. The focus of the entomology section has been the result demonstration trial implementing the Integrated Pest Management approach to pest and disease problems, basic biology of bug pests and predators including rearing studies, testing candidate chemicals, training scouts, and refining the I.P.M. approach in on farm trials. This has a further season to run with some changes when it is hoped that more definite recommendations can be made. Much of the work is ongoing such as testing candidate chemicals. The overall objective of both programs has been to improve yield and quality of nuts on farm and delivered to the factory.

Most of the above work is written into the N.A.R.P. contract research funding which is due to end in October 1992. Other parts (such as the Macadamia Reference Manual and testing of natural insecticides by Chancellor College) are outside the N.A.R.P. project. The successful completion of the N.A.R.P. project will mean that project resources such as vehicles and laboratory equipment will still be available to the research team provided funding is available to carry on further work. In order to obtain further funding, it is necessary to have a plan of future research needs on which to base funding proposals, hence the preparation of this paper.

Future Research Directions

There will need to be an emphasis on refining and improving current management practices to continue improving yield and quality of existing plantings. The implications are as follows

a) Agronomy

- continued nutrient monitoring and refining recommendations with an expansion of leaf analysis survey to include more sites and diagnostic sampling.

- continue with the irrigation trial at Kumadzi Estate where a result from irrigation should be possible due to the climatic conditions of that site and incorporate objective water status measurements.

- continue Cultar trial for another two seasons to gain sufficient data to analyse.

- continue basic phenological observation to build a better picture of the tree and clones in this environment.
- continue current clonal trials and evaluation of existing seedling block for potential clones using current clones for comparison.

- continue tree size/yield observation until entomology I.P.M. trial is completed.

- continue to monitor factory assessment information to follow changes and show areas where problems are occurring.

- commence pruning, tree size control trials to improve productivity and/or ease of management on existing trees.

- commence more objective tree performance assessment such as carbohydrate production and utilisation in order to quantify yield, small nuts and physiological problems with the nuts (this would be in conjunction with the above trials which should provide a useful data base).

Nutrient monitoring and refining will continue for two more seasons on a general basis and then move to specific trials or problems. The irrigation trial at Kavalani should continue for a further 4-6 years. The Cultar trial should continue for two more seasons. The phenological studies have one season's data from three sites and will need two more sites and three more years to collect sufficient data. Evaluation of seedlings will be completed next season and can be greatly reduced to the few promising trees identified. Clonal evaluation of newer clones has just started to produce results in 1991 and will take some years yet. Newly introduced clones will need to be propagated and planted into a new trial area - a long term study. The tree size/yield relationships have one season to run, giving three seasons data and will cease in that form. The techniques used will be applied in other trials. Factory information was previously an information gathering exercise for research and managers and was useful in defining problem areas. It is a management function and will cease after the current season. The pruning studies will be commencing in the coming season and will continue for at least four seasons, perhaps more. The objective tree performance studies will commence and continue for about four seasons also. During the coming years, much of the current work will be phased out as new work is commenced to balance the time available.

b) Entomology

- continue I.P.M. result demonstration trial for another season and analyse data to refine recommendations.

- continue pest and predator biology and rearing studies as a possible forerunner to wider biological control measures.
- continue screening of candidate pesticides (including natural types) for efficacy.

- continue quality monitoring for I.P.M. and other trials.

- continue disease investigation (e.g. flowers) and test control measures.

- continue economic analysis of pest and disease control measures.

- commence more detailed studies aimed at refining action levels for bug and borer pests.

- commence monitoring and reviewing spray application methods to improve efficiency.

- commence more detailed study of biology and ecology of bug pest, in particular Bathycoelia sp.

The I.P.M. program of field trials has one more season to run when three seasons data will be available. The enormous amount of data collected needs to be analysed in detail and will be the basis for refining recommendations as well as other entomological studies. The rearing of Bathycoelia sp. bugs and their egg parasites is proceeding very well and is providing valuable information into the biology of the pests. The work will continue and be the basis for more in depth studies. The screening of pesticides will be increased when the field work for the I.P.M. program is reduced and is ongoing. Quality monitoring will shift from the current emphasis of I.P.M. to other trials and will continue to be a major part of the work. Disease investigations are conducted by the Pathology Section who have limited time available but three years would be needed to obtain results. The economic analysis is ongoing and is an integral part of pest and disease control studies. As the field work load reduces at the end of the coming seasons, more emphasis will be placed on other points listed. A large data base will be available and new work can be phased in as time allows. The indepth nature of further studies will require a considerable amount of time.

All the points mentioned in (a) and (b) above could generally fit within the framework of existing resources with some modifications. The time frame would be approximately 2-4 years with some exceptions (e.g. screening test pesticides is ongoing). However, they are unlikely to lead to major changes or improvements in yields and kernel recoveries beyond a few percentage points at most sites - smallholders could be an exception. In order to obtain major improvements current limitations in the clonal performance and production systems must be addressed. This work tends to be longer term (i.e. 5-10 or more years) and may need specific resources or personnel as well as long-term funding commitments. The following will address current limitations.
c) Agronomy

- clonal selection based on imported clones (already in progress) and selection based on seedlings from known good parents planted in selected sites in Malawi. A strict selection criteria designed to meet the local (i.e. Malawian or area specific) requirements needs to be applied. This should include yield, quality, climatic adaption, pest tolerance, stress tolerance, tree shape, tree size and suitability for high density planting. Similar programs in Australia have produced good results and could be used as a guide. Relatively small numbers of trees have been used which reduced the inputs required to conduct the work and laboratory equipment is available. Research staff are now familiar with a number of assessment techniques from the quality and clonal studies currently undertaken. Australia could be a seed source. Twelve untried clones have been introduced and established in 1990/91.

- rootstock development based on selected, vegetatively propagated rootstocks. This should include the development of the three selections from B.A.R.S. (possible dwarfing rootstocks) and testing of others known to be successful such as 'Beaumont'. Selection criteria should include tree size control (e.g. dwarfing), uniformity, compatibility, rootstock/scion interactions and climatic adaption. It is likely that outside help and cooperation will be required to conduct this work because Malawi lacks suitable facilities and/or personnel. Cooperation with R.S.A., Australia or U.S.A. is possible and such work would be of mutual benefit to all macadamia industries.

- production systems based on high density plantings on a small area and/or permanent intercropping between tree rows. Both of these types of production systems have advantages in Malawi provided clones and rootstocks are suitable. High density plantings can greatly improve productivity per unit area but will require specialised equipment such as orchard type tractors and sprayers and a more intensive approach to management. 'Permanent' intercropping between tree rows offers flexibility in the production system. More specialised equipment may also be useful although existing clones and techniques could be used with some refinements. The long pay-back period on macadamia make both approaches worthy of study as a way of improving the economics of the crop.
d) **Entomology**

- overall pest and predator ecology (for estates and smallholders) studies in considerable depth are required. This would need to cover biology, ecology, habits and ranges of pests and predators and their respective roles in the overall pest and disease complex. This is time consuming and detailed work but is a necessary part of any biological control program.

- investigation into and development of a biological control program for macadamia. Such work can be expensive as well as time consuming and would require additional facilities and personnel. Most successful biological control programs have tended to be effective against a specific pest or disease so it is unlikely that all pests could be controlled in this way. However, current indications are that egg parasites of borer and bugs offers considerable potential and other agents may exist which have yet to be identified.

- host plant resistance is one area which offers the best long term means of pest and disease control. This will be an important part of the clonal development program. Smallholders in particular would benefit from such clones since their options in pest and disease control are limited. Although clonal susceptibility or otherwise can be observed in clonal trials, more detailed studies are required to prove tolerance or resistance. This type of study could be conducted as part of a biological control program provided facilities are available.

The programs outlined in (a),(b),(c) and (d) will need to be supported by Government and Industry. Similarly, a continued extension and training/self-help program will be needed in conjunction with the research effort. Smallholders will need to be targeted in much the same way estates have been to have a worthwhile impact and give this sector a share in the macadamia industry. Failure to address the longer term needs of the industry will lead to an industry which will be unable to compete in a competitive international market place.

**Cashews**

The effort put towards cashews by research has been small in recent years and cashews as an industry is struggling to survive. However, recent initiatives have led to the commencement of local processing at Mangochi and renewed interest in smallholders by the processor as well as an ADMARC sponsored smallholder scheme. Both sectors are seriously affected by a lack of suitable clonal material for reasonable yield and quality and, a lack of suitable pest and disease control measures especially for mosquito bug and
powdery mildew. Also, there is a general lack of basic agronomic information about cashew for the Malawian environments. Some work has been done on the pest and disease problems in the past and clonal selection is now taking place on a small scale. An agreement has been reached with the Northern Territory Department of Primary Industries and Fisheries (Australia) for a seed exchange program of superior clones.

Future Research Needs

Unless cashews are specifically targeted and funded accordingly, current efforts will have limited impact on the problems. However, the potential for rapid improvement is very good given the current state of the industry and the large areas of Malawi suitable for cashew growing. The future research requirements are similar to macadamia.

- continue and expand clonal selection for Malawi environments, concentrating on yield, quality, pest and disease tolerance, tree size and shape and propagation characteristics. Selection criteria should be strict and related to local conditions. Cooperation with Australia and neighbouring countries will be useful to get a wide selection of material and dwarf clones from Brazil could also be worthwhile.

- commence a more detailed study of pest and disease complexes of cashew. This is necessary to develop an I.P.M. approach and longer term biological control measures. The losses to insects are very high.

- commence a study of cashew production systems suitable for smallholder or larger estates including planting densities, intercropping, management practices, nutrition and nut storage. This would also give valuable agronomic information and encouragement to existing producers.

Cashews need a concerted extension, training and self-help program, especially to A.D.D.s and smallholders. Appropriate support will be required. The cashew industry has been more or less static or declining for many years until the initiative at Mangochi and Salima. The opportunity is there for improvement and a viable industry for smallholders and estates if the problems are tackled in the near future.
Macadamia Reference Manual
Macadamia integrifolia

by

W.M. Hancock
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MACADAMIA REFERENCE MANUAL

PREFACE:

Writing this manual has presented a challenge and also some difficulties. The challenge has been to relate the technical material available to conditions in Malawi and make suggestions on current production practices or ideas for the future. The difficulties have been to have enough technical material, especially that relating to the Malawian situation. Information on macadamia in general is limited and macadamia in Malawi more so. However field observations and grower comments are used and gratefully acknowledged as local knowledge is important. Information is subject to change and this manual will need to be updated in the future as more information becomes available. Section 7 has been contributed primarily by Ironside and Pero as this deals with their specific area of Pests and Diseases. A considerable amount of effort has been put into the preparation of the manuscript by Mr W R G Banda and Mr A E Mpasa. Members of the Tree Nut Growers Association Technical Liaison Committee have provided editorial Comment. All the above are gratefully acknowledged. I hope the manual will provide a sound technical base to augment the local knowledge of macadamia growing in Malawi as well as future research needs and directions.

I would also like to acknowledge the effort of Mrs Eunice Dakalira and Dr M St J Clowes of CDC for editing and final corrections and CDC for their assistance.

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TOWARDS A FARMING SYSTEMS APPROACH TO TREE NUT RESEARCH IN MALAWI

By

Wayne Mitchell Hancock

Submitted for the Award of Master of Science (Hons) from the University of Western Sydney Hawkesbury
1992
CERTIFICATE OF AUTHENTICITY

I hereby declare that this thesis is the result of my own efforts and that the work of others has been acknowledged in the reference list.

Further, I declare that this material has not been used towards an award at any other institution.

W.M. Hancock
SUMMARY

This thesis covers two years of field work in Malawi, Africa by the author as a Research Agronomist (Tree Nuts) for the Government of Malawi. The thesis is an action research type with core and thesis projects which are closely linked. The client group are large estate managers who control the tree nut industries in Malawi. The political, economic and historical perspectives are different from those commonly faced by Australian agronomists and the isolated location of the work make this a unique study.

The thesis includes sections on plantation or estate agriculture, farming systems approaches to research and problem solving, systems concepts in agricultural settings and action research concepts. These provide a framework for the study within the constraints of the government research system and industry expectations. The body of the thesis is a review paper presented to estate managers and co-researchers after one year's work. Relevant outcomes of the study are presented. The discussion draws together the outcomes through reflection on the process and methods used. Advantages and disadvantages are considered and risks, such as the dangers to the researcher of this type of study, are highlighted.
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- The Tree Nut Growers' Association members who accepted me and my ideas so well to allow the process of change to take place.

- The Ministry of Agriculture and Government of Malawi who provided the setting and in-country support for myself and family.

- The Australian International Development Assistance Bureau for their support in Australia which paid for the position.

- The people of Malawi for their warmth and tolerance of another 'msungu' (white person) in their country.
ACRONYMS

A.D.D.  Agriculture Development Division  
A.I.D.A.B.  Australian International Development Assistance Bureau  
A.S.A.S.  Australian Staffing Assistance Scheme  
B.A.R.S.  Bvumbwe Agricultural Research Station  
C.A.R.O.  Chief Agricultural Research Officer  
D.A.R.  Department of Agricultural Research  
F.A.O.  Food and Agriculture Organisation  
F.S.R.  Farming Systems Research  
F.S.R. & D.  Farming Systems Research and Development  
F.S.R. & E.  Farming Systems Research and Extension  
F.S.P.  Farmings Systems Perspectives  
I.P.M.  Integrated Pest Management  
N.A.R.P.  National Agriculture Research Program  
N.T.E.  Naming'omba Tea Estate  
O.D.A.  Overseas Development Aid  
P.O.  Professional Officer  
S.A.D.C.C.  Southern African Development Coordination Conference  
S.S.M.  Soft Systems Methodologies  
T.C.R.  Technical Component Research  
T.N.A.  Tree Nut Authority  
T.N.G.A.  Tree Nut Growers Association