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Technology and Employment Programme

**BIOTECHNOLOGY AND LABOUR ABSORPTION
IN MALAWI AGRICULTURE**

by

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and
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35396

Working papers are preliminary material circulated to stimulate discussion and critical comments.

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PREFACE

Within the framework of the Technology and Employment Programme, this study is the second in a series on forecasting the socio-economic and employment effects of specific biotechnologies in developing countries. While this study focuses on biotechnology application in tea production, the others broadly cover food and export crops, edible plant-oils processing, the dairy and animal feed industries, agriculture and agro-industries within a multi-disciplinary framework of analysis using both micro and macro level data.¹

The major objective of this study by Professor C. Chipeta, Head of the Economics Department, Chancellor College, University of Malawi, Zomba, Malawi and M.W. Mhango is to investigate the past effects and future prospects of the application of biotechnology on income and employment in Malawi. In response to the need for meaningful in-depth location-specific studies on biotechnology, the author focuses on a specific biotechnology in tea production - clonal and polyclonal tea.² The study convincingly demonstrates that with the adoption of these biotechnologies, labour intensity per unit of land increases by 22 to 25 per cent. This net gain in employment is brought about by increased labour use in the nursery and planting operations involving the development of the clones and their establishment in the field. Since the biotechnology plantations are relatively younger in age labour use in pruning is higher compared to the traditional Indian hybrid tea. As expected, labour-use in weeding and plant protection is lower for the biotechnology plantations due to reduced use of herbicides and pesticides. A significant change in the structure of employment is noted with a higher proportion of labour allocation for nursery and planting and lower proportions for weeding and plant protection under the new technology compared to the traditional one.

Under the new technology, a general decline is observed in the use of intermediate material inputs per unit of land or labour although the input cost structure is more or less stable. As wage rates under both the technologies remain unchanged, greater labour absorption under the new technology has led to a higher share of labour (wage bill) in the total factor income. The application of biotechnology contributes to improving the nation's balance-of-payments situation in two ways: (a) substantial savings on imported inputs like pesticides, fertilisers and herbicides and (b) higher export earnings since the polyclonal tea fetches higher prices in the international market.

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1. These include a conceptual piece, an overview of plant-oils processing, a comparative study between Mexico and the U.S.A. on impact of specific biotechnologies in the sugar and dairy industries; overall rural employment implications in China, the Philippines and Mexico; an assessment of the contribution of biotechnology in combatting malnutrition in Nigeria; and diffusion studies for specific commercial and export crops in Kenya.
 2. A plant with the most desirable characteristics is selected and a piece of it - a bud for example - is treated in the laboratory to reproduce an exact genetic copy of the parent.

The study also concludes that the scale of the operation is not a crucial factor in the diffusion of the new technology although most of the land planted with tea by the smallholdings has polyclones. In monetary terms the new technology is attractive as its products fetch a higher international market price. From considerations of increasing employment and labour's share in factor income and improving the country's trade balance the biotechnology can make a significant contribution.

Iftikhar Ahmed

BIOTECHNOLOGY AND LABOUR ABSORPTION IN MALAWI AGRICULTURE

INTRODUCTION

Objectives and scope

The objective of this study is to investigate the past effects and future prospects of the application of new biotechnology on income and employment in Malawi. The purpose of such a study stems from the need to empirically test whether the change in biotechnology is of a kind which can be said to serve Malawi's economic objectives of raising agricultural production, income and employment, and of improving the balance of payments by increasing net foreign exchange earnings. The application of new biotechnology can influence income and employment opportunities directly or indirectly.¹ Direct effects consist of those arising from (i) research and development (R and D) aimed at the development of new plants which embody new technology, and (ii) the growing of new crops. Indirect effects result from (i) production activities where such products are used as inputs, and (ii) activities which supply inputs into their production. It is also necessary to consider the income and employment multiplier effects of all these activities. But because these longer term effects are difficult to quantify, they are not discussed in this paper.

In assessing the effects of the advanced biotechnology, it is necessary in this case to pay attention to substitution effects because the new varieties of tea cause displacement of other crops, mainly old varieties of tea. To this end, we shall attempt to investigate the extent to which the new varieties of tea displace other crops and the new income and employment effects of this substitution.

Since the effects of new biotechnology are likely to be influenced by a number of factors that are pertinent to the process of technology innovation and diffusion, this study also considers the types of biotechnology that have been applied, by whom they have been applied, and how they have been developed or adapted and diffused throughout the country. Furthermore, it examines the role that the Government has played in the technological innovation and diffusion process and in controlling or promoting various effects of the new biotechnology. Our working hypotheses are that the use of new biotechnology (i) increases the production of tea, (ii) increases tea exports and imports of agricultural inputs, (iii) directly and indirectly increases income, and (iv) directly and indirectly increases employment. The focus of the study is on tea because advanced biotechnology is used in propagating new species of this crop.

Methodology

This study has made use of information that has been collected through discussions with officials of the Ministry of Agriculture, the Smallholder Tea Authority, agricultural research stations and private organisations that look after the interests of estate-grown tea. Use has also been made of data and information collected from tea companies through a questionnaire survey. Tea estates are controlled by 21 firms which own 61 estates at present. After pre-testing on six firms, the questionnaire was sent to all the tea firms which were asked to fill one questionnaire for all estates that share the same tea factory and hence have common records.

Secondary sources of data and information have, for tea estates, included annual reports of the Tea Research Foundation, and the Tea Association of Malawi. For smallholder tea growing, they have included annual reports of the Smallholder Tea Authority and agro-economic surveys. General sources have included the Annual Economic Survey, the Statement of External Trade, Economic Reports and the Employment and Earnings Annual Report. Data has been processed by computer and desk calculators. Where necessary, use has been made of correlation and regression techniques.

BIOTECHNOLOGIES IN THE TEA INDUSTRY

Biotechnological change

Malawi is better endowed with cultivable land, a favourable climate and unskilled labour than with minerals, capital and technical skills. As a result, the economy of the country is dominated by agriculture which provides livelihood for close to 90 per cent of the country's population, contributes just under 40 per cent to the country's Gross Domestic Product (GDP), provides 88 per cent of its exports and accounts for no less than half of recorded paid employment. Within this sector, smallholder agriculture, mostly subsistence, dominates estate agriculture as a producer of foodstuffs, but not as a producer of export crops.

Because of the sheer size of the agricultural sector, both short-term and long-term changes in the economy are to a large extent influenced by developments in agriculture. Trends in the volume and value of the main crops in Malawi can be gauged from Table 1 below.

Table 1: Volume and value to growers of
selected marketed crops in Malawi

	Volume (tonnes)		Value (K'000)	
	1975	1985	1975	1985
Tea	24,846	37,357	21,100	91,399
Tobacco				
Flue-cured	10,678	16,196	19,332	59,927
Burley	7,147	31,503	7,462	55,141
Fire-cured	12,242	20,823	4,437	20,619
Maize	29,245	271,567	1,250	33,247
Groundnuts	32,807	18,235	5,221	12,375
Coffee				
Estate		3,373		11,867
Smallholder		268		1,338

Sources: National Statistical Office (NSO), Malawi Statistical Yearbook 1985, Coffee Association of Malawi and Smallholder Coffee Authority.

Tea, along with tobacco, sugar and groundnuts, is a very important commercial crop. In 1983, for example, it contributed 21.1 per cent to the country's exports. During the same year it employed 9.7 per cent of the country's total employed labour force. In addition, tea growing alone contributed K21.9 million to the gross domestic product of K770.7 million in 1983.

The expansion in total tea hectareage in recent years has been modest, from 16,200 hectares in 1973 to 18,600 hectares in 1985 or 1.2 per cent expansion per year, because of limited availability of land. Over the same time period, production has increased from 23.6 million kilogrammes to 40.0 million kilogrammes largely owing to the expansion in hectareage and improved management practices on estates. The increase in the average local and London auction prices of tea have generally been comparable with the increase in the general level of prices, but there have been considerable price fluctuations. Given the limited availability of land, increases in output can be achieved through improved management practices and through the introduction of improved varieties of tea. But to what extent the adoption of improved tea species increases yields and production has not been systematically investigated. Also not known are the effects of this new tea biotechnology on income, employment, exports and imports of inputs.

To assist smallholder farmers in growing tea, the Government set up the Smallholder Tea Authority (STA) in 1967. Before that date, smallholder farmers had already started growing tea in a pilot scheme. By 1972, over 800 hectares of tea had been planted and production had started, mainly in Mulanje and Thyolo Districts. Since then, there has been steady expansion with total hectareage standing at 2,361, production of green leaf at 13 million kilogrammes and the number of growers at 4,815 in 1986. The average farmer has less than one hectare of land under tea.

The STA fosters smallholder tea growing by imparting skills to farmers through dissemination of technical advice, provision of improved inputs through long-term and seasonal credit, by passing on to them the results of research, and by purchasing green leaf and delivering it to factories. The STA does not have a factory itself. The tea sold to it is resold to the Malawi Tea Factory Company which has a factory in Mulanje. In Thyolo, the tea is resold to privately owned tea factories. The STA is controlled by a board composed of representatives of government, one of whom serves as the chairman; representatives of smallholder farmers and the estate tea sector; and independent members, selected for their expertise in finance and commerce.

Rather unsuitable natural conditions, an inappropriate management structure and unfavourable prices were responsible for the unsatisfactory record of the STA at the beginning. The low prices paid by the STA weakened incentives. As a result, farmers did not harvest all the crop and production was always below target. Prices have since been adjusted upwards. But other problems remain. These include:

- (a) the capital cost of establishing smallholder tea farms which weighs heavily on the farmers' repayable debt from the time that they start harvesting the crop;
- (b) lack of adequate suitable land in Mulanje and Thyolo Districts to permit expansion of land under smallholder tea;
- (c) shortage of paid seasonal labour, partly due to competition from the estates that can afford to pay the established minimum wage; and

- (d) the large financial deficit of the STA that makes it difficult for the organisation to expand the programme or to continue with the fertiliser credit scheme to capital deficient farmers.

Although tea has been grown in the country on a large scale since the 1920s, yields were very low until the late 1960s when the use of improved plant material was introduced and integrated into the tea industry. The first tea plantations were under the small-leaved China type tea which had a number of drawbacks. China tea produces very small, tough shoots which are hard to pluck and contribute a high percentage of fibre in made tea. The yields obtained from this type of tea are very low. The first step towards improving tea production was the introduction of Indian hybrid and Assam type cultivars. These have moderate sized and very large leaves, respectively. Their shoots are soft and large, hence higher yields than those realised from the China type are possible. Seed gardens using Betan type pure Assam tea were thus established in the early 1960s with a view to producing seedling populations which had large shoots and were therefore high yielding.²

Work on vegetative propagation was started in the late 1950s when clonal selection was carried out on existing seedling populations in the field at Mimosa Tea Research Station, Mulanje. Selection was based on the degree of tolerance to a bad drought experienced in 1957. These selections were given MFA (Mimosa Field Selection) numbers accordingly. More selections were carried out at Swazi (now Nsuwadzi) Tea Research Station but for quick and vigorous recovery from prune. These were assigned SFS (Swazi Field Selection) numbers. All these selections were later assessed for rooting ability, yield and quality.³

A systematic plant improvement programme by deliberate breeding followed by clonal selection was initiated in the early 1960s. The first hybridisation programme was started in 1961 when controlled pollinations between the selected China type and Assam type generative clones were carried out. Selection work on the progenies from these crosses led to the production of a very popular clone PCI (Progeny Clone I). The parents of this clone were M9 (an Assam type clone with fairly large leaves and relatively high yielding) and C1 (a China clone). Both clones have a high quality tea-making potential, although the China type has an additional flavour (TF) value in its made tea and produces a very bright infused leaf and strong, brisk liquor. It is an above average yielding clone but has problems in the nursery with rooting. However, PCI, along with a field selection SFS 204, has remained an outstanding clone. Further attempts to improve tea production in Malawi have therefore been geared at improving both the quality and yield over these early clones.⁴

In its early days, the Tea Research Foundation of Central Africa through its plant improvement section strongly emphasised quality rather than yield in its breeding objectives. However, the Tea Research Foundation has reviewed its policy and now considers both quality and yield as its primary breeding objectives and this therefore affects its line of research discipline. The progress under this revised policy has been extremely satisfactory. While the early unimproved plant material on average yielded only around 1,000 kg made tea per hectare in its sixth year, the improved clones of the same age in the field can yield as much as 2,000 kg made tea per hectare without irrigation and up to 5,000 kg made tea per hectare with irrigation. The selection procedure has involved employing the established selection criteria for quality; these include chloroform test for fermentability and theaflavin analysis in made tea for overall quality of made tea. For yield the process involves yield examination of the seedling bushes for vigour, leaf and shoot size, branching, potential of plucking points, resistance to pests and

diseases and climatic stress. Although yields and quality of Malawi tea have gone up dramatically, the results indicate that there is still room for improvement in both the characteristics.⁵

As explained in the above paragraph, the main breeding objective in the 1960s and early 1970s was quality. During that time, nearly all production was by well established commercial tea estates which could easily afford all the management and agronomic inputs required for successful growing of tea. The plant improvement section, in conjunction with the biochemistry section, therefore devoted nearly all its research efforts towards establishing reliable selection criteria for quality. These criteria, which include chloroform test, catechin analysis, theaflavin and total colour analysis, have been successfully established and utilised to improve the quality of our tea.⁶

Now that the structure of the industry has changed through the introduction of smallholder tea growers, who account for more than 8 per cent of the hectareage under tea, the Tea Research Foundation has put forward a special consideration in its breeding policy in order to cater for the needs of these smallholders who may not have the same facilities as the tea estates. Apart from looking for yield and quality in general, the plant improvement section now seriously selects for resistance to insect pests such as *Helopeltis*, Thrips and Red Spider Mite. Drought resistance, an early vigorous return from prune and off-season vegetative growth are other special considerations in the present breeding and clonal selection programme.⁷

Since selection criteria for quality have already been well established, efforts are now concentrated on establishing reliable selection criteria for yield and the other characteristics mentioned above. Once reliable selection criteria have been established, the rate of success in clonal selection will be greatly enhanced.⁸

So far, all the breeding and clonal selection work has been carried out using conventional breeding methods in which genetic variability is created through sexual hybridisation. There is still such a vast amount of genetic variability in tea which has not yet been fully exploited that probably the employment of advanced genetic engineering techniques, novel techniques, such as embryo culture, egg transformation and other parasexual methods which are essential where sexual hybridisation is unsuccessful.⁹

At the moment, controlled pollinations between the selected elite generation clones are carried out every flowering season to transfer the desirable characters possessed by the two parents into the offspring. The process involves first identifying the generative clones which possess the required characters, e.g. resistance to insect pests or diseases, quality, etc., then carrying out crosses to ensure the right combinations. The progenies obtained from such crosses are then screened for vigour, leaf and shoot size, resistance to insect pests and other required field characteristics and quality. The promising bushes are later assessed for rooting ability and ease of propagation in the nursery and for survival and establishment in the field. Each clonal plot is plucked and yield recorded separately for at least three plucking seasons. Leaf samples are miniature manufactured separately to check on their fermentation time and TF (Tea Flavour) level in made tea. They are tasted to examine their briskness and strength. Promising selections are assigned PC numbers and undergo strenuous screening for quality, yield, resistance to insect pests and climatic stress in clonal field trials.¹⁰

The promising selections in the observations now go into properly designed field trials as potential clones. Their field performance is tested with and without irrigation in Mulanje. These potential clones are also tested in Thyolo, and in each case they are planted together with the established clones such as SFS 204 as a control. Each trial, with at least 20 plants per plot, would be replicated at least five times usually using a randomised block or latin square design depending on the terrain of the field. These trials run for at least five plucking seasons prior to limited releases of the promising clones. The Tea Research Foundation has recently initiated a programme of testing the potential clones deemed suitable for smallholder farmers under their own limited management.¹¹

The main users of the new biotechnology

Generally, little progress seems to have been made toward adopting improved varieties of tea on estates. During the 1984/85 tea-growing season, only about 9 per cent of the land planted with tea had clonal tea, while only 16 per cent had polyclonal tea. During the same season, 19 per cent of the area planted with tea had local varieties and 56 per cent had Indian hybrid tea (see Table 2).

Table 2: Area planted with tea by type of tea at the conclusion of the 1984/85 season in hectares

Type	Local	Indian	Poly-clonal	Clonal	Cumulative total
Planted seasons:					
Prior to 1920/21	913	-	-	-	913
1920/21 to 1929/30	1,917	770	-	-	3,600
1930/31 to 1939/40	727	1,247	-	-	5,574
1940/41 to 1949/50	17	1,588	-	-	7,179
1950/51 to 1954/55	8	1,604	-	-	8,791
1955/56 to 1959/60	10	1,435	6	-	10,242
1960/61 to 1964/65	-	2,500	47	2	12,791
1965/66 to 1969/70	-	1,208	264	41	14,304
1970/71 to 1974/75	-	63	1,116	580	16,063
1975/76 to 1979/80	-	42	1,102	488	17,695
1980/81	-	-	163	83	17,941
1981/82	-	-	141	117	18,199
1982/83	-	-	9	90	18,298
1983/84	-	-	19	85	18,402
1984/85	-	-	54	160	18,616
<hr/>					
TOTAL	3,592	10,457	2,921	1,646	
	19%	56%	16%	9%	

Source: Price Waterhouse, Survey of the Tea Industry in Malawi 1985, P.4.

Whether or not a tea estate has established improved varieties of tea has partly to do with the age of the estate. Most of the old estates are found in Mulanje and Thyolo Districts. Most of these are planted with local and Indian

hybrid tea. Some have replanted parts of the land under these species with polyclonal and clonal tea, but this still represents a small percentage of the land planted with tea. The rate of replanting is low. For five estates included in the case study, the average rate of replanting is 5 hectares per year. In contrast, two out of the three tea estates in Nkhata Bay District that have been established more recently grow polyclonal and clonal tea respectively, because they came into being when tea biotechnology had changed.

The major reason for the low rate of adoption of clonal tea is financial and this was mentioned in all the completed questionnaires. At current tea prices and input costs, if an estate were to replace all old varieties of tea with clonal species, it would take 10 years or more before it would earn any profit. In the meantime, liquidity and the cash flow would come under strain, and the estate would increase dependence on loan finance. It is even doubtful whether the estate would be able to raise the initial capital for the replanting programme to start with. If all estates were to do this at the same time, the financial problems would be compounded (since most firms own several estates), certain physical assets would be underutilised in the initial years, and the country would export less hence lose foreign exchange, apart from risking losing the market.

At present, tea is suffering from the universal trend of low commodity prices, which has also affected the whole range of metals, fibres and foodstuffs. It is fortunate, perhaps, that tea is not the worst sufferer so far, but the outlook is not reassuring. Despite reduced production worldwide, tea prices have fallen, probably the first time that this has happened recently indicating that new forces are influencing the market, as yet dimly understood, that have no connection with global figures of supply and demand. It is possible to find explanations. One is the low oil price leading to diminished purchasing power in the Middle East which has been the growth market absorbing all earlier extra production. The second is the Iran-Iraq War which has diverted resources away from tea (and other consumer goods) to military equipment. The third is increased sales from China. However, these may only be contributory reasons, while underlying all commodities caused by sluggish economic growth. It is not easy to see how the situation will improve either in the short or medium term unless some natural disaster affects a major producing area.¹²

The tea industry suffers from substantial cost increases all the time. These cost increases have accelerated recently. They are fuelled by the rapidly declining value of the Malawi Kwacha against the currencies of the country's trading partners. Policy-makers assert that devaluation is designed to help the export of tea by making the product more competitive. They believe that tea will become cheaper, and that the world, therefore, will increase demand for it. The tea industry disputes this assertion, saying that as an international commodity, tea has a given world market price that is not affected by changes in the value of a currency of a single producer. Besides, Malawian tea is used in blending with other teas. Therefore, demand for Malawian tea cannot increase unless there is an increase in demand for tea in general.¹³

The tea industry admits that there is a windfall profit every time the currency is devalued. But the benefit is both temporary and illusory. The cost of imported inputs rises, and soon catches up with the increase in revenue expressed in domestic currency. In addition, taxation removes half the benefit, while the remaining half is barely sufficient to finance the working capital required for the increase in costs, let alone the purchase of capital assets required for replacement or improvement.¹⁴

Cost increases are also attributable to reliance on longer land routes to the South African sea ports instead of shorter land routes through Mozambique which are no longer readily available to Malawi. As a result, the tea industry is suffering from very high transport costs that absorb a substantial proportion of the export value of the product.¹⁵

The Government does not have the resources to come to the aid of the tea industry by way of subsidies. Because of the limited sources of revenue, it cannot afford to offer tax relief to the tea industry either. Therefore, the tea industry must help itself. According to the Chairman of the Tea Association of Malawi, the options available to the tea industry are limited. All it can do is to become more efficient and to place a better product on the market. There is still good demand for quality teas at remunerative prices, whereas poorer teas are neglected and sell at a derisory level if they do not find a market. The price differential between the best and worst teas is wider than ever, and spells the difference between profit and loss. There would appear to be considerable opportunity to upgrade Malawian teas, even in the short term with existing facilities, and indeed without impinging on the high yields which may have been achieved. To achieve this, the industry must improve management which should lead to higher yields and therefore lower costs, and improve quality through better manufacture. The urgency of these steps is now greater than before.¹⁶

If sufficient unused land were available, estates would not have to cut old tea bushes and hence lose revenue, in adopting clonal tea species. They would simply plant clonal tea on unused land, wait for returns while enjoying profit on old tea. This would minimise both financial and economic hardships to the country.

There is not much land left unused in Mulanje and Thyolo Districts as confirmed by the fact that all six estates in these districts included in the study stated that they were using all their land. In these districts, it is not easy to lease land for purposes of cultivating tea as there is a shortage of all types of land. In Nkhata Bay District, although the tea estates may not have much unused land themselves, there is some surplus land that can be leased.

Table 3 shows the use of the land in the hands of the tea industry. The data in the table clearly show that the amount of land which can be used for future tea cultivation is small. Some land (5.8 per cent) is used for growing other permanent crops like coffee. Because of the recent high price of coffee, some estates have replaced tea with coffee on their land. Even bananas are known to pay better than tea when tea prices are as low as they are at present. Fuelwood, which occupies 15.5 per cent of the land, is essential for the processing of tea, but the land under other forest (3.7 per cent) must be seen to be competing with tea for land.

Tea can be grown either from seeds or from leaf cuttings. Many commercial estates use leaf cutting material or grow vegetatively propagated (VP) tea plants. In most cases these are dependent on irrigation for establishment in the field. Unfortunately, irrigation is not sufficient on some estates or is not possible at all. Lack of adequate foreign exchange also limits the ability of the country to import irrigation equipment.

Because the Smallholder Tea Authority was established during the era of the biotechnological revolution in the tea industry, it adopted polyclonal tea which is easier to establish and transport than clonal tea. Therefore, most of the 4,815 smallholder growers in Mulanje and Thyolo Districts grow polyclonal tea. However, the Tea Research Foundation (TRF) is currently

Table 3: Total area of land controlled by the
tea industry at the end of the 1984/85 season

	Private sector	Small- holders	Non- private sector	Total	Per cent
Tenure:					
Estate freehold land	38,858	26	2,660	41,544	84.0
Estate leasehold land	5,050	10	-	5,060	10.0
Licensed/customary land	-	2,749	-	2,749	6.0
Total	43,908	2,785	2,660	49,353	100.0
Utilisation:					
Planted with tea	15,846	2,349	421	18,616	37.7
Developed with tea bearers	80	8	1	89	0.2
Fuelwood plantations	7,318	308	21	7,647	15.5
Other forest development	1,823	-	-	1,823	3.7
In use for other permanent crops	2,854	-	-	2,854	5.8
Suitable for future tea planting	2,685	-	824	3,509	7.1
Other uses, including roads, housing, gardens, factory areas not yet developed or unusable	13,302	120	1,393	14,815	30.0
TOTAL	43,908	2,785	2,660	49,353	100.0

Source: Price Waterhouse, Survey of the Tea Industry in Malawi 1985, p.2.

engaged in a series of field trials of clones especially suitable for smallholder farmers growing their own Vegetative Propagation (VP) nurseries, and present replacement or expansion is with VP plants rather than polyclones. The total hectareage is 2,361.

While it is possible for smallholder tea growers to establish tea gardens using their own resources, the majority take out long-term loans for buying planting material, fertilisers, tools and insecticides. They also take out short-term seasonal credit.

The diffusion of the new biotechnology

The dissemination of the new tea species and improved cultivation practices on tea estates is the responsibility of the Tea Research Foundation (TRF). The TRF disseminates the results of its research through a regular newsletter. Initially, new tea species are supplied by the TRF after multiplication. Once that is done, estates multiply the new plants on their own. The TRF also holds regular seminars to discuss research results with potential users. In Zimbabwe during the 1986/87 season, for example, the TRF held eight seminars, three on tea plucking, four on productivity and one on

fertilisers. In addition, there are the annual field days. There were four field days during the 1986/87 season of which one was laid aside for senior managers. The executives of the tea companies to whom talked are satisfied with these activities of the TRF.¹⁷

The diffusion of the new tea varieties among smallholder tea growers is the responsibility of the Smallholder Tea Authority (STA). In other words, the benefits of research by the TRF are passed on to smallholder farmers through the STA. Examples are the development of special clones, advice on plucking, proper use of insecticides and the correction of nutrient or trace element deficiencies by special fertiliser application.¹⁸

As might be expected in a project with over 4,800 growers, the STA does have problems mainly with some of the tea growers who are inefficient. The STA believes that these do not represent a large percentage of smallholders and, with the assistance and co-operation of District Disciplinary Committees, steps can and are being taken to invigorate inefficient growers. In cases of continued neglect and lack of co-operation in following correct cultivation methods, plots can, at the discretion of the Minister of Agriculture, be reallocated to growers who will care for them and work them properly.¹⁹

Problems are experienced in teaching growers and instructing them in proper cultivation practices. However, as STA staff become more experienced and as the use of pamphlets, publications, films and the radio increases, it is believed that progress is being made and a core of experienced growers who can pass on skills to others is being built up. Furthermore, the STA has recently set up an Evaluation and Training Department whose job is to monitor the performance of both the authorities and the growers and to arrange training programmes to match the needs of both growers and STA staff.²⁰

In both Mulanje and Thyolo Districts, the STA has established Teaching Plots which are planted and maintained according to the practices recommended to the growers. These plots are used for both demonstration to growers and training periods for STA extension and conservation staff.²¹

Communications and transport pose problems because of the large area and scattered nature of holdings. But, as more roads are put in and existing roads improved, the problem should recede. The STA network of field staff and the coverage it gives to growers are constantly being adjusted and improved. A high percentage of field staff is now mobile. They use their own motorcycles purchased with the assistance of the STA.²²

Employment in the tea industry

Traditionally, agriculture provides the bulk of recorded permanent wage employment in the country. In 1982, for example, agriculture accounted for 52 per cent of such employment.²³ The bulk of this employment is on tea and tobacco estates as shown in Table 4.

The expansion of estate agriculture and the resultant growth of employment opportunities has added an important dimension to the rural economy. In 1970, there were 220 estates occupying 2 per cent of the cultivable land. By 1978, the number of estates totalled 1,107 occupying 13 per cent of the cultivable acreage. Of these, over 50 were tea, while 524 were flue-cured tobacco, 556 barley tobacco, and one sugar estate. The average number of employees engaged by commercial agriculture has similarly expanded, from 42,600 in 1969 to 189,300 in 1985, an annual average growth rate of 21.5 per cent.

Table 4: Employment in commercial agriculture^a
('000 persons)

Year	Tea estates	Tobacco estates	Other private commercial agriculture	Total
1969	30.1	8.1	4.5	42.6
1970	30.7	13.1	4.8	48.6
1971	32.6	15.9	5.2	53.7
1972	32.5	20.2	6.8	59.5
1973	35.2	24.6	11.5	71.4
1974	35.2	22.5	17.1	74.8
1975	36.8	20.5	28.8	86.1
1976	36.7	30.6	28.5	95.8
1977	37.9	71.7	23.2	132.8
1978	37.6	87.5	23.2	148.3
1979	39.4	105.5	33.9	178.8
1980	38.1	106.8	36.2	181.1
1981	36.6	92.7	27.9	157.2
1982	37.0	105.7	36.5	179.2
1983	37.7	116.3	43.2	197.2
1984	39.1	104.8	33.8	177.7
1985	42.8	116.7	29.8	189.3

a Before 1977, only firms employing over 20 employees were included. After 1976, all firms are included. Figures for 1977 and 1978 include about 18,300 workers not previously recorded.

Source: National Statistical Office, Annual Economic Surveys and Reported Employment and Earnings Annual Report, various issues.

Employment growth in the tea industry has generally been upwards but more modest than employment growth in the tobacco industry. Total employment in the tea industry grew by 42.2 per cent, implying an annual average growth rate of 2.6 per cent between 1969 and 1985. The annual average growth rate was slightly higher at 3.1 per cent between 1969 and 1979 than between 1980 and 1985 when it was only 2.5 per cent.

Until 1976, tea was both in absolute and relative terms the most important employer of labour in agriculture. In 1969, for example, it employed 30,100 workers or about 71 per cent of total employment in commercial agriculture. Since 1976, the tea industry has lost ground to the tobacco industry. In 1980, for example, it employed 38,100 people or 21 per cent of total employment in commercial agriculture. Apart from tobacco, it is also facing stiff competition from other commercial agriculture.

The present section examines the effects of changes in biotechnology on production, incomes, employment, imports and exports in the tea industry.

The data

The data analysed in this section was obtained from eight tea estates which completed and returned the questionnaire. As such, the data constitutes a case study rather than a random sample. Besides, most of the eight estates were not able to complete all questions. Thus, the data in the tables may not represent information from all the eight estates.

Two measures of tea output are used in this study. One is made tea measured in metric tonnes. This has been included to highlight actual physical yields of tea against expected yields per unit of land. The other is the gross value of tea output measured at constant prices. For clonal tea, output has been valued at the average market price realised between October 1986 and September 1987 as reported by the tea estates. The same is the case for Indian hybrid tea. For polyclonal tea, output has been valued at the average price realised between July 1986 and July 1987 as reported by the Smallholder Tea Authority. Because of wide disparities in the prices of the various tea species, yields measured in monetary terms make more sense when considering the economic viability of improved species of tea.

Land (N) is defined in terms of area (measured in hectares) along with the tea plants growing within the confinement of that area. All the districts where tea is grown in Malawi meet the soil and climatic requirements for its cultivation. Whatever differences exist in the quality of the soil and in climatic conditions are believed to be insignificant and of little consequence.

The number of tea plants in a hectare varies from estate to estate. For all eight estates, the range of variation was from 6,817 to 10,000 tea bushes per hectare. Within each tea species, the range of variation was smaller. For Indian hybrids, the range of variation was from 8,430 to 9,250; for polyclonal tea, it was from 6,817 to 8,197; and for clonal tea, it was from 8,269 to 10,000 per hectare.

The density of tea plants per hectare depends on the spacing design. In the early years of the tea industry, the spacing design that was most popular was four feet by four feet square. Subsequently, other designs including hedge planting, gained popularity. Changes in the spacing patterns may have been induced by the expectation of better yields. However, it is doubtful that a larger number of tea plants per hectare will necessarily be associated with a higher yield per hectare.²⁴

Labour (L) is measured in man-days as reported by the estates. There is no disaggregation into male, female or adolescent labour. Total labour input is the aggregation of labour input in each operation. For tea estates which grow polyclonal and clonal tea, labour includes that which is engaged in nursery work and new planting.

The intermediate material inputs (I) whose value has been totalled are fertilisers, chemicals for plant protection (pesticides, insecticides, fungicides and weedicides), fuel and power and others, including baskets, bags, etc. While fixed capital (K) represents depreciation of physical assets and the maintenance of the same.

Analysis of production

Technology levels

For the purpose of this study, technology level is associated with the type of tea that is grown. Indian hybrid tea will be denoted by T_1 , polyclonal tea by T_2 and clonal tea by T_3 . Not only is the average yield per hectare of the various species of tea different, the input combinations also differ. The distribution of estates by their technology level and their average size is shown in Table 5.

Table 5: Number of tea estates by level of technology and by average size

Level of technology	Number of estates using technology	Average size of land under each technology in hectares
T_1	7	284
T_2	5	53
T_3	6	56

The change in technology on tea estates almost entirely represents the variation in the application of biological innovations. As such, one must expect to find an increase in the use of intermediate material inputs per hectare (i.e., an increase in the coefficient I/N as intermediate material inputs are substituted for land). Ideally, this should be associated with an increase in land and plant productivity (O/N). As regards yields measured in monetary terms, this is true only in respect of clonal tea (see Table 6).

Table 6: Intermediate material inputs, gross physical output (metric tonnes) and gross value of output per hectare by level of technology

Level of technology	I/N*	O/N	O/N*
T_1	307.70	2.33	4,683.30
T_2	330.98	1.54	4,406.40
T_3	444.87	1.75	5,040.00

* In Malawi Kwacha.

Average physical yields of clonal tea are below the 2 metric tonnes per hectare that the Tea Research Foundation expects from unirrigated land and far below the 5 metric tonnes per hectare it expects from irrigated land. The same is the case for polyclonal tea. Actual field yields are below potential for a number of reasons. Many polyclonal and clonal tea bushes are relatively young, hence they have not reached their maximum production potential. Clonal

tea bushes are reported to be taking a long time to mature. Besides, many estates are not applying intermediate inputs, such as fertilisers, in sufficient amounts (this being a problem of managerial practices).

Smallholder tea is grown on three types of land: public land consisting of all land that was made available by government from virgin land, forest reserves or former estate land; customary land that was not used prior to the cultivation of tea, was fallowed for a long period of time or was virgin land granted by village headman; and customary land which was used for growing other smallholder crops. The mean yield is highest on public land and lowest on used customary land. At the beginning of the 1970s, these yields were estimated as 1,049 kg per hectare on public land, 691 kg per hectare on unused customary land and 567 kg per hectare on used customary land. These yields refer to made tea. The higher yield on public land is attributable to the higher nutrient value of the soil and the good quality of the clearing work by the Smallholder Tea Authority staff.

Overall, annual smallholder yields of polyclonal tea are always below targets set by the Smallholder Tea Authority (see Table 7). These should be explained in terms of the untimely performance of certain farm operations and the low level of crop husbandry, particularly the low quality of weeding and plucking.²⁵ In 1984/85, for example, as much as 22.3 per cent of the green leaf plucked in Thyolo District was unacceptable. In Mulanje District, the unacceptable leaf was smaller at 6.9 per cent. The average for the two districts was 14.6 per cent. As between different years, variations in yields to a large extent reflect differences in the amounts of rainfall. Between 1975/76 and 1984/85 the initial fall in yields was due to inadequate price incentives. These had subsequently improved, hence the reversal in the yield trend.

Table 7: Smallholder green leaf yields
compared with targets in kilograms

Season	Target	Actual	Actual as per cent of target
1975/76	2,394,453	2,301,620	96.1
1976/77	3,165,566	2,887,508	91.2
1977/78	4,058,987	3,305,584	81.4
1978/79	5,032,590	4,040,117	80.3
1979/80	6,368,488	5,216,937	81.9
1980/81	7,421,161	5,923,101	79.3
1981/82	8,486,109	6,079,338	71.6
1982/83	9,526,614	6,985,937	73.3
1983/84	10,513,687	7,757,201	73.9
1984/85	11,298,100	10,208,975	89.6

Source: The Smallholder Tea Authority Annual Report 1984-85, p.5.

Despite the higher average price of 264 tambala per kilogramme applied to estate polyclonal tea as against 219 tambala per kilogramme applied to Indian hybrid tea, the gross value of the former per hectare is smaller than that of the latter. Only the much higher average price of clonal tea per kilogramme of 319 tambala makes a difference, despite the lower physical yield of clonal tea compared with Indian hybrid tea.

Simultaneously, given the importance of the knowledge of applying the inputs of biological innovations, one should expect to find more of these innovations to be associated with an increase in output per hectare. The principal manifestation of this association would be seen in the economy in the input-use per unit of output (i.e. biological innovation substituting all or some traded inputs). This economy could take two forms: (a) a reduction in the total factor cost per unit of output where less of one factor but more of another is used, and (b) a reduction in the total factor cost when less of each factor per unit of output is used. If the comparison was between T_2 and T_1 levels of technologies, for example, T_2 would be more profitable than T_1 in the first case but superior in the second.

In Table 8, quantities of land, labour, intermediate material inputs and capital flow services per unit of output are presented. It can be seen that the inputs of land rises as one moves from the T_1 to the T_3 level of technology, reaching its peak in the T_2 level of technology. Similarly for labour and capital inputs. The only partial exception to this general pattern occurs in the case of intermediate material inputs. Here there is a decline between T_1 and T_2 , but the input at the T_3 level of technology exceeds the inputs at each of the T_1 and the T_2 levels of technology. What these facts tell us is that there is a shift in the production function as one moves from T_1 to T_2 and T_2 to T_3 levels of technology. Since output is measured in physical units, we would tend to conclude that the path of change in technology is from superior to inferior techniques. If output were valued in monetary terms, we would probably conclude that the change in technology was from inferior to superior techniques as far as clonal tea is concerned.

Analysis of variance

In order to assess the relative importance of different factors to changes in technology, an analysis of variance is attempted. Estates are classified by T_1 , T_2 and T_3 levels of technology and the degree of variation of the variable listed below is tested.

Table 8: Average factor input (land, labour, intermediate material inputs and capital flow services) per metric tonne of tea output by level of technology

Level of technology	Land in hectares	Labour in man-years	Intermediate material inputs (K)	Capital flow services (K)
T_1	0.37	0.85	256.47	97.86
T_2	0.66	1.77	220.16	130.67
T_3	0.60	1.59	259.17	118.27

A.	(i)	Man-days of labour per hectare	(L/N)
	(ii)	Intermediate material inputs per hectare	(I/N)
	(iii)	Capital flow services per hectare	(K/N)
B.	(i)	Size of estate	
	(ii)	Number of tea bushes per hectare	(B/N)

By taking each input per unit area of land in A, we abstract from the scale of operation. Land area being homogenous, we can see the variations in each input in combination with the same amount of land. In B, we test whether the size of estate varies significantly with change in technology. We also test whether the number of tea bushes per hectare varies with change in the level of technology.

Results of the analysis are presented in Table 9. It can be seen that L/N, I/N and size of estate vary significantly with the level of technology. We can, therefore, conclude that in the type of technology by T₁, T₂ and T₃, capital flow services per hectare (K/N), and the number of tea bushes per hectare (B/N) are not significantly different.

Regression Analysis

Through the following regression analysis, the significance of the species of tea grown is tested. A log linear regression model of the form:

$$\log y = a + b_1 \log x_1 + b_2 \log x_2 + \dots + b_n \log x_n$$

in which the proxy variable P represents technology level or species of tea grown will be used. P will take the value 1, 2 and 3 for estates in the T₁, T₂ and T₃ levels of technology.

Four functions are presented:

- (i) $O/N = f(I/N, L/N)$;
- (ii) $O/N = f(I/N, L/N, B/N)$;
- (iii) $O/N = f(I/N, L/N, P)$; and
- (iv) $O/N = f(I/N, L/N, K/N, P)$.

These functions show that intermediate material inputs and the number of bushes per hectare are highly significant in explaining variations in output. Labour and the level of technology are also significant in some of the equations.

Factor proportions

Changes in factor proportions or movement along the production function are shown in Table 10, in terms of coefficients I/N, L/N and I/L. Labour inputs do not apply to fertilising because this operation is carried out by aerial spraying.

Intermediate material inputs per unit of land are smaller at each successive level of technology than at the T₁ level. There is, however, an increase between the T₂ and T₃ levels. This is also the case for intermediate material inputs per unit of labour. The lower levels of intermediate material inputs per unit of land or labour at the T₂ and T₃ levels of technology as compared with the T₁ level is attributable to a number of factors.

Table 9: Results of analysis of variance for testing the effects of technology change on a number of selected variables

Variable	Sum of squares due to technology	Degrees of freedom	Mean sum of squares due to technology	Sum of squares due to error	Degrees of freedom	Mean sum of squares due to error	Variance ratio F
Labour per hectare	95552.82	2	47776.41	33663.26	15	2244.22	21.29***
Material input per hectare	65718.54	2	32859.27	85049.09	15	5669.94	5.80***
Bushes per hectare	12200688.00	2	6100344.00	0.0	15	0.0	0.0
Size of estate	105003.34	2	52501.67	7.17	15	0.48	109785.09***
Capital flow services per hectare	0.05	2	0.03	77865.63	15	5191.04	0.00

*** Significant at the 1 per cent level.

Explanatory variables	Regression coefficients			
	Function I	Function II	Function III	Function IV
Intermediate material inputs per hectare (I/N)	0.37046*** (0.12244)	0.29719*** (0.11381)	0.38181*** (0.12812)	1.20455*** (0.16365)
Labour (man-days) per hectare (L/N)	-0.21678 (0.34432)	0.45595 (0.41192)	-0.03225 (0.57709)	1.26010*** (0.40547)
Bushes per hectare (B/N)	-	1.02947** (0.41703)	-	-
Capital flow services per hectare (K/N)	-	-	-	-0.47884 (0.13133)
P as proxy for technology	-	-	-0.03255 (0.08076)	-0.12325** (0.04951)
Constant	7.74517*** (2.19923)	-5.55474 (5.73757)	6.51314* (3.79193)	-4.30294* (2.77630)
R ²	0.23817	0.38689	0.20653	0.79588

* Significant at 10 per cent level.

** Significant at 5 per cent level.

*** Significant at 1 per cent level.

Figures within brackets are standard errors of the estimates.

First, the level of fertiliser application at the T₂ level is much less than at the T₁ level. This might mean that polyclonal tea is less receptive to larger amounts of fertilisers or that the right amount of fertiliser is simply not applied. At the T₃ level of technology, the amount of fertiliser is simply not applied. At the T₃ level of technology, the amount of fertiliser used per hectare is not significantly different from the one used at the T₁ level, but it is certainly larger than the amount used at the T₂ level.

Secondly, the amount of other chemicals used up per hectare is lower at both the T₂ and the T₃ levels than at the T₁ level. The chemicals concerned are those used in plant protection and include pesticides, fungicides and herbicides. Polyclonal and clonal tea plants are more resistant to diseases than Indian hybrids. Therefore, they require fewer material inputs for their protection.

Table 10: Change in factor coefficients I/N, L/N and I/L
at different levels of technology

Factor coefficients	T ₁	T ₂	T ₃	Change at T ₂ level compared with T ₁ level	Change at T ₃ level compared with T ₂ level	Change at T ₃ level compared with T ₁ level
I/N ^a	514.43	330.98	444.87	-183.45	+113.89	-69.56
L/N (Man-days)	671.51	828.70	837.11	+157.19	+8.41	+165.60
I/L ^a	0.78	0.40	0.53	-0.38	+0.13	-0.25

a In Kwachas (local currency).

Thirdly, the amount of fuel/power required per hectare of polyclonal and clonal tea also is lower. This may be explained in terms of the smaller amount of plant protection required at the T₂ and T₃ levels of technology and the generally smaller number of tea bushes per hectare of tea at the same levels of technology compared to the T₁ level of technology.

Lastly, the amount of other material inputs (including baskets, bags and other packaging materials) required per unit of land at the T₂ and T₃ levels of technology is around half of the amount required at the T₁ level. This has to do with the lower physical yields of polyclonal and clonal tea per hectare.

At all levels of technology proportionately more of the expenditure on intermediate material inputs goes into fertilisers, fuel and power than into other chemicals and other intermediate material inputs. Compared to T₁ and T₃, the proportion spent on fertilisers at T₂ is less, while the proportions spent on fuel and power and other chemicals are larger (see Table 11).

The labour input per unit of land increases as one moves from the T₁ to T₂ and from T₂ to T₃ levels of technology. Whereas virtually no labour is required for Indian hybrid nursery and planting work, some is required in connection with the establishment of polyclonal and clonal tea. Besides, the pruning of polyclonal and clonal tea bushes which are relatively young requires more labour per hectare than the pruning of Indian hybrid tea bushes. Otherwise, less labour is required per hectare in weeding, protecting and in plucking polyclonal and clonal tea.

In all comparable operations, labour cost per hectare of polyclonal and clonal tea is much less than per hectare of Indian hybrid tea. In weeding, for example, it is K3.48 as against K15.00. And in plant protection, it is K5.00 and K8.00 in polyclonal and clonal tea, respectively, as against K9.00 in Indian hybrid tea. The planting of Indian hybrid tea is more widely spaced than that of other species and accounts for the observed difference in labour costs.

Table 11: Proportion of expenditure on components
of intermediate material inputs per unit of land
in tea cultivation by levels of technology
(per cent)

Intermediate	Levels of technology		
	T ₁	T ₂	T ₃
Fertilisers	69.9	64.1	72.4
Other chemicals	7.9	10.6	7.8
Fuel and power	18.3	22.6	17.7
Other intermediate material inputs	3.9	2.7	2.1
Total	100.0	100.0	100.0

Analysis of incomes

Direct income effects

The average yield of Indian hybrid tea on the case study estates for the six year period 1980/81 to 1985/86 was 2.33 metric tonnes of made tea per hectare. Corresponding yields for polyclonal tea and clonal tea were 1.54 metric tonnes and 1.75 metric tonnes respectively. In terms of total production on these estates, this implies that total production was in 1985/86 211.19 metric tonnes lower for polyclonal tea and 193.44 metric tonnes lower for clonal tea than what it would have been if all the land had been devoted to Indian hybrid tea. Altogether, tea output was 403.63 metric tonnes lower.

According to our estimates, the loss in revenue arising from this was K270,989.44 in respect of polyclonal tea. This was only partially offset by a gain of K160,046.40 for polyclonal tea. Hence, a net loss of K110,943.04 was sustained in revenue. In terms of value added, the net loss was K35,426.81.

As far as wage income is concerned, there is no difference in wage rates between workers depending on the species of tea on which they work. (There may in fact be little differentiation of work by species of tea.) The average wage rate applicable to manual workers on all tea estates in 1985/86 was 95.2 tambala per man-day. The 1,189,498.2 man-days attributable to Indian/local tea on six of the case study estates earned around K1,132,402.29 in cash in 1985/86; while the 175,312.8 man-days attributable to polyclonal tea earned around K166,897.79 and the 99,060.0 man-days attributable to clonal tea earned around K94,305.12. Since polyclonal tea requires 23.4 per cent more labour per hectare than Indian/local tea, if all the land was under polyclonal tea, wage income of K1,132,402.29 would have been up by K264,982.14. On the other hand, if the land under Indian/local tea had all been under clonal tea, the relevant wage income would have been up by K279,703.36 since clonal tea requires 24.7 per cent more labour per hectare than Indian/local tea. Information on marginal propensities to consume is not available to enable us to estimate the indirect effects of these changes on total income through the multiplier process.

Since polyclonal and clonal tea is grown on land which should have been under Indian and local tea, the net gain in employment is only 41,023.2 man-days for polyclonal tea and 24,467.8 man-days for clonal tea in respect of the case study estates. The corresponding net gains in wage income are K39,054.08 and K23,293.36 for polyclonal tea and clonal tea respectively.

Research related to the development of new tea biotechnology is a significant source of income in the country. For example, the 933 people that were employed by the Tea Research Foundation in 1986 earned some K704,371 between them.

Indirect income effects

As a result of the reduction in imported material input requirements, value added in the distribution sector was lower by K96,172 in 1985/86. Of this amount, K27,382 represented wages and K63,381 represented net profit. Malawi does not manufacture the fertilisers and chemicals which are the most important imported material inputs, hence it is not necessary to estimate the net impact of their domestic manufacture.

Analysis of employment

Direct employment effects

In 1985/86, manpower requirements per hectare in field operations were 70.8 man-days in growing Indian/local tea, 86.34 man-days in growing polyclonal tea and 87.11 man-days in growing clonal tea. In other words, polyclonal and clonal tea field manpower requirements were greater than those of Indian/local tea by 15.54 man-days or 21.9 per cent and 16.31 man-days or 23.0 per cent respectively. If we are to apply to these figures the total hectareage under each type of tea in 1985/86, we obtain net employment gains due to polyclonal tea of 45,394 man-days and due to clonal tea of 26,846 man-days.

Inputs which displace labour are used in operations carried out for plant protection. For example, chemical weedicides for controlling weed growth and power sprayers for spraying pesticides, insecticides or fungicides substitute labour directly. As there are various types of weeds and methods of eradicating them, the amount of labour used in weed control at any level of technology depends on the intensity of the weed control activity and on whether there is more use of manual weeding than chemical eradication. Which method is adopted depends on the intensity of weed growth and the type of weeds that require the more intensive approach. It also depends on the approach to plant protection that is followed, that is, on the importance given to plant protection and especially to weed control in the organisation of operations and in the scheme of operationwise resource allocation.

The data shown in Table 12 indicates that there is a net increase in labour input per hectare in nursery and planting between the T_2 and T_3 levels of technology. In other words, the development of clones and their establishment in the field requires more labour than the development and establishment of polyclonal tea. At present, there is no planting of Indian hybrid tea. Hence the large increase in the labour input per hectare in nursery and new planting between the T_1 and T_2 and the T_1 and T_3 levels of technology: in pruning, there is a net increase in the amount of labour input per hectare between T_1 and T_2 and the T_1 and T_3 levels of technology because of the relatively younger age of clonal and polyclonal tea bushes which consequently require more frequent pruning than Indian hybrid tea bushes. However, between the T_2 and T_3 levels of technology, there is a net decrease in the amount of labour inputs per hectare in pruning implying that clonal tea bushes require less frequent pruning than polyclonal tea bushes.

In weeding, there is again a net decrease in the amount of labour input per hectare between the T₁ and T₂ and the T₁ and T₃ levels of technology implying that there is more use of chemicals in controlling weeds at the T₂ and T₃ levels than at the T₁ level. Between T₂ and T₃ there is, however, a net increase in labour input per hectare in weeding. In plant protection, the pattern is similar, a net decrease in labour input per hectare between the T₁ and T₂ and the T₁ and T₃ levels of technology because of greater use of mechanical means at the T₂ and T₃ levels of technology, and no net change in labour input per hectare between the T₂ and T₃ levels of technology. So too in plucking, a net decrease in the labour input per hectare between the T₁ and T₂ and the T₁ and T₃ levels of technology because of lower yields of tea at the T₂ and T₃ levels of technology, and a net increase in labour input per hectare between the T₂ and T₃ levels of technology because of a higher yield of tea at the T₃ level of technology compared to the T₂ level. Considering all operations together, there is a net increase in the labour input per hectare between the T₁ and T₂ and between the T₂ and T₃ levels of technology, as well as a net increase in the labour input per hectare between the T₂ and T₃ levels of technology.

Organisational improvements

Organisational improvements in the use of labour can come about through general rationalisation of labour and improvement in supervision in each operation through reallocation of labour between operations in such a way that the total input of labour per unit of output is reduced. Both ways may be used simultaneously.

With respect to the latter, one can see from Tables 12 and 13 that for the case study tea estates as a whole, there is a proportionate as well as an absolute decline in the labour input per hectare in weeding, plant protection and plucking between the T₁ and T₂ and also between the T₁ and T₃ levels of technology. In nursery and new planting there is a proportionate as well as an absolute increase in labour input between T₁ and T₂, T₁ and T₃ and T₂ and T₃ levels of technology. In pruning the proportionate and absolute increases in labour input per hectare is between the T₁ and T₃ levels of technology only; between T₁ and T₃ and between T₂ and T₃ there is a decline. These differences are attributable to variations in yields and in cultural practices at different levels of technology.

Table 12: Change in labour (man-days) input per hectare
in different operations by level of technology

Operations	Between T ₁ and T ₂	Between T ₂ and T ₃	Between T ₁ and T ₃
1. Nursery and new planting	+18.3	+6.8	+25.1
2. Pruning	+15.2	-15.4	+0.1
3. Weeding	+6.8	+2.8	-4.5
4. Plant protection	-1.9	0.0	-1.9
5. Plucking	-9.6	+7.1	-2.5
Total	+15.2	+0.8	+16.3

Table 13: Percentage distribution of labour input (man-days)
per hectare by operations and level of technology

Operations	Level of technology		
	T ₁	T ₂	T ₃
1. Nursery/new planting	0.0	21.2	28.3
2. Pruning	51.7	60.3	42.1
3. Weeding	17.4	6.4	9.0
4. Plant protection	4.2	1.3	1.3
5. Plucking	26.7	10.8	18.8
Total	100.0	100.0	100.0

Pruning, in terms of labour input, is clearly the most important activity in tea accounting as it does for over half of the total labour input. The direction in which labour input per hectare for pruning changes with an advance in technology very largely determines the change in the total labour input in tea estates. Estates do not seem to have made a systematic effort to rationalise the labour input in this activity. The data in Table 13 indicates that an advance in technology between the T₁ and the T₂ level is accompanied by more labour input per hectare in pruning, but an advance in technology between the T₂ and the T₃ level of technology is accompanied by a reduction in the labour input per hectare in the same activity.

Indirect employment effects of technological change

As we have pointed out already, direct employment measured in man-days increases from 671.51 at the T₁ level of technology to 828.70 at the T₂ level of technology and 837.11 at the T₃ level of technology. This includes labour in all field activities connected with tea cultivation, including nursery work and new planting. The establishment of clonal tea is a long-term process that will last into the next century. As such, it has become a permanent feature of tea cultivation. This justifies its inclusion in manpower data.

Indirect employment attributable to a change in technology arises in three main ways: through manufacturing activities where tea is used as an input, through a forward linkage induced by an increase in income and consisting of additional saving and investment and additional consumption and expenditure; and through a forward linkage with industries which provide the additional non-labour inputs required for the new technology.

Since the net effect of introducing polyclonal and clonal tea is to reduce the output of made tea, the change in biotechnology has the effect of reducing employment in tea manufacturing. It has been estimated that for the case study estates, the loss in employment in tea manufacturing arising from a net reduction in made tea of 440.63 metric tonnes was 36 jobs.

Employment generated by savings and consumption induced by additional wage income

An advance in technology from the T_1 level to the T_2 and T_3 levels will cause income to increase because it is accompanied by an increase in the amount of labour required per hectare. The wage rate applicable at the various levels of technology is the same and, hence, it does not account for differences in incomes at different levels of technology. Given a rise in income, it is reasonable to believe that there would be an increase in savings and investment. Unfortunately, it has not been possible to estimate either the increase in savings or investment. Therefore, estimates of the indirect employment that might result from this source, which may not be negligible, are not offered.

Additional consumption expenditure due to a change in technology constitutes additional demand for consumer goods. When this is met through increased productivity, this causes additional labour to be employed and additional income to be generated. The second round of consumption expenditure starts another round and so it goes on until the original impetus is exhausted. The initial increase in consumption expenditure in this case arises out of the difference in all factor incomes at the T_2 level of technology compared with T_1 and at the T_3 level of technology compared with T_1 . We shall limit ourselves in this study to increases in wage income.

When the income of an individual or community rises over time, the additional consumption depends on the marginal propensity to consume (MPC). But when comparison is being made between two individuals or groups, having different levels of income at the same time, additional consumption attributable to the difference in their incomes will be given by their respective average propensity to consume (APC).

Because of a lack of data on marginal and average propensities to consume in respect of tea estate workers, on the division of expenditure between products of agriculture or rural industries and on the products of urban industries, it has not been possible to estimate the indirect income and employment resulting from the additional income and consumption expenditure at the T_2 and T_3 levels of technology compared with the T_1 level.

In addition, as a result of the reduction in imported material input requirements, it is estimated that employment in the distribution sector was 37 man-years below what it would be if only Indian hybrid tea, which requires more imported material inputs than polyclonal tea, was grown.

Analysis of imports and exports

On the basis of the information contained in completed questionnaires, the value of imported inputs in 1985/86 has been estimated at K564.95 per hectare of Indian hybrid tea, K396.98 per hectare of polyclonal tea and K546.10 per hectare of clonal tea. This implies a saving of K167.96 per hectare of polyclonal tea which is significantly larger than the saving of K18.84 realised per hectare of clonal tea. Applying the total hectareage under polyclonal and clonal tea in 1985/86 to these figures, gives total savings of K490,611.16 and K31,010.64 respectively. The main imported inputs to which these savings relate are fertilisers, other chemicals used in plant protection, fuel, power and others, mainly packaging materials. The amount spent on all these items per hectare of polyclonal tea is the lowest, followed by clonal tea except with regard to fertilisers where there is no significant difference between the amount used per hectare of clonal tea and Indian hybrid tea.

The reduction in imported material input requirements has the following important consequence. Demand for limited foreign exchange resources to purchase those inputs is curtailed which is welcome in view of the limited resources of foreign exchange available to the country.

The average price realised at the London auction market of polyclonal tea grown by smallholder farmers is higher than the average price realised at the same market by all tea from Malawi. Between July 1984 and June 1985, the difference between the two was, on average, 24 pence per kilogramme. The world average price during this period was only slightly higher than the average of Malawi polyclonal tea grown by smallholder farmers. The difference was only 4 pence per kilogramme. Assuming that if the smallholder farmers whose tea was processed by the Malawi Tea Factory Company had not produced the 1,345,711 kilogrammes of made polyclonal tea, but 1,345,711 kilogrammes of Indian hybrid tea, foreign exchange earnings from the export of the crop would have been lower by 11.9 per cent.

There is no data on the average prices of the different types of tea that are grown by estates that would facilitate estimates of gains in export earnings arising from the change in technology from Indian hybrid tea to polyclonal tea or clonal tea. Only a handful of estates provided the relevant data. But given the diversity of markets (London, Limbe and others) and modes of marketing (auctioning, private treaty, etc.), it was felt that the data provided by a small number of estates would not be representative of the whole industry.

For the case study estates, if all land had been under polyclonal rather than Indian hybrid tea, export earnings would have been greater by 20.7 per cent in 1986/87. On the other hand, if all land had been under clonal tea rather than Indian hybrid tea, export earnings would have been larger by 45.7 per cent in the same year.

THE ROLE OF THE GOVERNMENT

The Government has always played some role in the development of new tea biotechnology because of the importance of tea to the country's economy. More recently, that role has increased because of the Government's interest in raising smallholder tea production. The Government is represented on the Governing Body of the Tea Research Foundation (TRF), but more importantly, it assists the TRF in obtaining research scientists and equipment from abroad under various technical and financial aid programmes with foreign governments and international organisations. As the TRF embarks on new research programmes aimed at further improving tea species and tea manufacture, the Government will play an even larger role.

It has not been the practice of the Government in the past to provide extension services to estate agriculture, in the belief that this sector can take care of itself. The diffusion of new biotechnology, therefore, is left entirely in the hands of the TRF. Following the finding that many tobacco estates lack technical expertise and competent management, the Government's views on this subject have changed. As a result, the Government may soon start providing extension services to all estates. It may also start training managers for employment on estates.

In planting new land with clonal tea or in replacing old species with clonal tea, tea estates incur heavy investment expenditure. The Government gives generous investment and depreciation allowances to encourage business firms, including tea firms, to undertake investment. The recent reduction in

customs duties on raw materials and capital goods has increased the incentive to invest. On the other hand, there have been changes in the tax law that may be less favourable to the tea industry, such as the higher income (profits) tax on foreign-owned companies, the tax on dividends in the hands of the recipient company and the introduction of cross border taxes on remittances by expatriates. On balance, the tea industry believes that the investment climate has deteriorated.

Then there is draft legislation towards a new Water Resources Act which, if it is enacted, would make life extremely difficult for the tea industry by inhibiting the development of water for irrigation on the estates. The tea industry's objection to the proposed legislation has been made clear to the Government, but it remains to be seen whether its views will guide this legislation into more acceptable channels.

For diffusing new tea biotechnology among smallholder growers, the Government relies on the Smallholder Tea Authority (STA). This is a statutory body that is answerable to the Government upon which it relies for some of its funds. The expansion of the activities of this organisation may be constrained by the limited availability of funds on the Government. But the Government has often successfully negotiated and passed on to its foreign loans and grants to ease financial constraints.

Much of the success of the smallholder tea project is due to the continued interest of the Life President who is the Minister of Agriculture. The STA also has an excellent working relationship with the office of the Regional Party Chairman with whom it works closely, and gets support and encouragement from the Tea Association of Malawi.

Unlike investment in estate agriculture, investment in smallholder agriculture does not benefit from fiscal and monetary incentives. Since the Government is considering extending these general incentives to medium- and small-scale business enterprises, they may be extended to small-scale agriculture as well.

The Tea Association of Malawi was established in 1934 to represent the entire tea industry. Before that date, the Nyasaland Tea Research Association had existed for six years and had research as its main objective. The Tea Association co-ordinates the main activities of the tea industry and presents a united voice. It has always taken great interest in the need for research; and from 1959 until July 1966, it was entirely responsible for administering and financing the research stations. It collects statistics from growers, manufacturers, dealers and others on matters relating to the tea industry; and publishes documents on tea to help improve production and marketing. The Tea Association also supports the work of the Tea Research Foundation by securing financial support from international organisations.

Every company in the tea industry is a member of the Agricultural Employer's Association which is mainly concerned with labour relations in tea and other agricultural industries and acts as a consultative and advisory body to all its members.

CONCLUSIONS AND RECOMMENDATIONS

Analysis of information secured from the Tea Association of Malawi, the Tea Research Foundation, and the tea estates that filled in and returned a survey questionnaire leads to the following conclusions and recommendations:

- (a) the observed biotechnology used in Malawian tea is of the simple variety involving cross-breeding and selecting plant species with desired characteristics, such as high yield, improved quality and resistance to drought or diseases. Vegetative propagation rather than cloning by tissue culture is used to multiply the chosen varieties of clonal tea both at the research station and in the field;
- (b) historical factors are more important than anything else in determining whether a particular tea planter is growing improved species or not. The scale of operation is not a crucial factor. Availability of land and financial resources constrain the further adoption of improved tea species. Estimates of future hectareage, production and yields have been made (see Table 14). The data in the table indicate that total hectareage will increase by 2.1 per cent only between 1986 and 1990. This reflects the land constraint to which we have already referred. Tea production estimates indicate an increase of 32.9 per cent according to the members and an increase of only 7.1 per cent according to the Tea Association of Malawi. The corresponding increases in yields are 7.4 and 28.2 per cent, respectively. The Tea Association's estimates are believed to be more reliable. But it is not known how much of the increase in production will be due to (i) the expansion in hectareage, (ii) the planting of clonal tea, (iii) improvement in management and (iv) better application of other inputs, including fertilisers and irrigation. Given the lack of adequate unused land, lack of capital, low tea prices and high produced input and transport costs, the tea industry is unlikely to switch completely from local and Indian hybrid tea in the near future. Most tea estates seem to be replacing old with new varieties at a rate of 2 per cent per year. At this rate of replacement, it will take 45 years to complete the exercise;

Table 14: Estimated future tea production^a

Season ending in	1986 (actual)	1987	1988	1989	1990
Total tea area (hectares)	18,149	18,203	18,241	18,382	18,533
Weight:					
Members estimates (kg 000s)	33,061	40,684	41,515	42,818	43,941
TAML ^b estimates (kg 000s)	42,000	41,000	42,850	44,100	45,000
Average yield based on members estimates: kgs per hectare	2,208	2,235	2,276	2,309	2,371
Indexed to 1964 = 100	191	194	197	202	205
Based on TAML estimates: kgs per hectare	2,147	2,417	2,535	2,638	2,572
Indexed to 1964 = 100	186	209	220	228	238

a Based on existing conditions and trends.

b Stands for Tea Association of Malawi.

Source: Price Waterhouse, Survey of the Tea Industry in Malawi, 1985, p.6.

- (c) most of the land planted with tea by smallholder farmers has polyclones. These species were adopted by the Smallholder Tea Authority because of ease of establishment and transport. To replace all the existing hectareage with clones would be very costly in terms of the amount of new investment required and foregone production, incomes and foreign exchange earnings. Besides, farmers would have to learn how to handle new species, especially when they are in the nursery. Clonal tea is relatively new and one does not know how it is going to stand in the field, especially under smallholder conditions. The Smallholder Tea Authority has allowed farmers to fill in with clones and all new expansion is with clonal tea. However, for a variety of reasons, including lack of suitable land and other resources, expansion is limited. So it is unlikely that there will be a large switch to clonal tea in the near future;
- (d) the observed physical yield of estate polyclonal and clonal tea is lower than the physical yield of Indian hybrid and local tea. It is also lower than the yields of the same tea species expected by the Tea Research Foundation under field conditions. This phenomenon reflects the relatively younger age of the polyclonal and clonal tea bushes, the slow growth of the clonal tea species that have been adopted, application of inadequate material inputs and lack of irrigation. In order to raise yields and hence close the gap, tea estates will have to plant faster growing clonal tea species, apply more material inputs and use irrigation wherever possible. The physical yields of smallholder polyclonal tea are also lower than expected yields because of inadequate application of fertilisers and the low quality of soil and crop husbandry and plucking. The Smallholder Tea Authority must successfully grapple with these problems if yields are to rise;
- (e) in monetary terms, the yield of clonal tea is larger than the yield of Indian hybrid and local tea because of the higher market price of clonal tea. For this reason, it is in the best interests of tea estates to grow more clonal tea than Indian hybrid and local tea. In contrast, the yield in monetary value terms of polyclonal tea is smaller than that of Indian hybrid and local tea because of the lower market price of the former. For this reason, estates do not find it attractive to plant more polyclonal tea;
- (f) a major concern for policy purposes, therefore, arises out of the constraints faced by estates and smallholder tea growers in adopting clonal tea. These growers can cultivate clonal tea either by planting new land or by replacing other varieties of tea with clonal bushes. Given that the availability of suitable land is a big constraint in Mulanje and Thyolo Districts, further expansion should be encouraged in Nkhata Bay District where suitable land and irrigation water exist. Acceleration of the pace of replanting existing fields with clones is dependent upon the improvement in the financial environment. According to the International Monetary Fund, the prices of tea, which are currently depressed, should pick up during 1988-89.²⁶ This will give tea growers some incentive but, in itself, will not be enough. Every assistance should therefore be given to the Tea Research Foundation to work on techniques of tea manufacture with a view to devising more efficient methods; while the tea industry must continue to improve management practices to raise yields and lower production costs. There is also a need to moderate the growth of imported input costs by refraining from devaluation of the currency. Furthermore, there is a need to make credit available on easy terms to those tea firms which would like to adopt clonal tea; and to review the disincentive effects of the income tax on foreign-owned firms and the tax on dividends in the hands of the recipient company;

- (g) the research and development (R and D) associated with improving tea species is a comparatively significant source of both income and employment in Malawi;
- (h) according to the Tea Research Foundation, employment in the tea industry should rise with an advance in technology. The observations that we have made support this view with respect to the amount of labour required per hectare in nursery work, planting, pruning, but not in plucking, plant protection and in weeding. However, the net employment effect is positive;
- (i) the indirect employment created by advances in tea biotechnology is negative both in tea manufacturing activities and in the distribution sector which supplies intermediate material inputs to the tea industry;
- (j) differences in workers' earnings on tea estates by level of technology have not yet been observed. This implies that the differences in workers' earnings on estates growing different tea species are due to differences in the numbers of workers and not the wage rates; and
- (k) as polyclonal and clonal tea require fewer imported inputs and fetch higher prices on the world tea market, their contribution to the country's balance of payments is positive. However, the gain from higher export prices of polyclonal and clonal tea is not being fully realised. Several tea estates, with small amounts of clonal tea, mix it with the larger quantities of Indian, local and polyclonal tea during manufacture. As a result, they do not benefit from the prices which higher quality clonal tea would fetch on the world market. The net balance-of-payments effect could therefore be negative. With polyclonal tea grown on estates, the net balance of payments effect could also be negative. As far as smallholder polyclonal tea is concerned, the story is different. This type of tea requires fewer imported inputs per hectare than clonal tea. Because the Malawi Tea Factory Company is able to manufacture pure polyclonal tea which fetches higher prices than Indian hybrid or local tea, the impact of smallholder polyclonal tea on the balance of payments must certainly be positive.

NOTES

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