THE
TEA RESEARCH INSTITUTE
OF
CEYLON

Annual Report for the Year
1964
Part II

Published by
THE TEA RESEARCH INSTITUTE OF CEYLON
ST COOMBS, TALAWAKELE, CEYLON
1965

The Tea Research Institute of Ceylon

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Secretary :

Mr G. M. Sparkes

The Tea Research Institute of Ceylon

Staff as at 31st December 1964

Director	...	A.W.R. Joachim, OBE, BSc, PhD (Lond), FRIC, Dip Agric (Cantab)
Deputy Director	...	J. A. H. Tolhurst, BSc (Reading)
Agricultural Chemistry		
Agricultural Chemist ...	...	J. A. H. Tolhurst, BSc (Reading)
Research Assistants ...	...	S. Sivasubramaniam, BSc (Cey)
		W. Bandaranaike, BSc (Cey)
Senior Technical Assistant	...	V. Mendis
Assistants	...	T. C. Z. Jayman
	...	E. O. Stuart
	...	(Mrs) B. I. de Silva, BSc (Cey)
		S. Sunderalingam, BSc (Poona)
		K. Govindasamy
		T. Kularatna, BSc (Cey)
Plant Propagation		
Adviser in Plant Propagation	...	A. V. Richards, BSc (Lond), MSc (Calif), Dip Agric (Cantab), AICTA, (Trinidad)
Research Assistant ...	...	*S. Kulasegaram, BSc (Cey)
Research Assistant (Plant Breeding)		A. R. Sebastiampillai, BSc (Cey)
Assistants	...	H. R. Solomon
		A. L. J. de Croos
		D. D. Kroon
		H. B. Ratnayake (Hantane)
Agronomy		
Chief Agronomist ...	...	H. N. Hasselo, Dr Ir (Wageningen), Dip Aerial Survey (Delft)
Research Assistants ...	...	*W. M. W. B. Manipura, BSc (Cey)
		S. Sandanam, BSc (Cey)
Assistants	...	S. M. Kandasamy
		M. Sikurajapathy, BSc (Cey)
Low-Country Service		
Low Country Scientific Officer	...	L. H. Fernando, BSc PhD (Lond)
District Advisory Officer	...	J. V. Sabanayagam, BSA (Toronto)
Research Officer (Agronomy)	...	S. C. Wanigaratne, BSc (Cey), PhD (Wales)
Technical Assistants ...	...	J. I. H. Bandaranayake
		K. H. G. Gunapala (Kottawa)
		H. D. Jayasinghe
		H. H. Samarakoon
		N. Yogaratnam, BSc (Alahabad)
		U.P. de S. Waidyanatha, BSc (Cey)
Chief Clerk	...	R. I. Pereira
Stenographer	...	S. K. P. Tambimuttu
Clerk	...	K. P. Gunawardena
Plant Physiology		
Plant Physiologist ...	...	U. Pethiyagoda, BSc (Cey), PhD (Lond), DIC
Research Assistant	...	S. Kandiah, BSc (Cey)
Senior Technical Assistants	...	M. Piyasena
		S. Nagarajah, BSc (Cey)
Assistants	...	N. S. Rajendram, BSc (Madras)
		G. M. H. B. Wijetunge
		S. Krishnapillai, BSc (Cey)
Nematology		
Adviser in Nematology	...	A. Kerr, BSc (Edin), PhD (Adel)
Acting Nematologist ...	...	N. Shanmuganathan, BSc (Cey), PhD (Lond)
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Senior Technical Assistant	...	M. K. Vythilingam
Assistants	...	P. A. John
		S. Samarajeewa
		A. R. M. Hassim
Plant Pathology		
Adviser in Plant Pathology	...	A. Kerr, BSc (Edin), PhD (Adel)
Plant Pathologist	...	N. Shanmuganathan, BSc (Cey) PhD (Lond)
Research Officer ...	...	R. L. de Silva, BSc (Cey), PhD (Lond), DIC
Senior Technical Assistants	...	W. W. Redlich, BSc (Cey)
		P. V. Arulpragasam, BSc (Madras)
Assistants	...	S. Murugiah
		W. R. F. Rodrigo, BSc (Cey)
Entomology		
Entomologist	...	J. E. Cranham, BA (Cantab), DIC
Research Officer ...	...	D. Calnaido, BSc (Cey), PhD (Lond), (Hantane)
Research Assistants ...	...	D. J. W. Ranaweera
		*W. Danthanarayana, BSc (Cey)
Senior Technical Assistant	...	E. F. W. Fernando, BSc (Cey)
Assistants	...	C. Shanmugam
		A. Kathiravetpillai, BSc (Cey)
		K. Thirugnanasuntharan, BSc (Cey), (Hantane)

STAFF—*contd.*

Biochemistry	
Biochemist	G. W. Sanderson, BSc (Calif), PhD (Nott)
Biochemist (Manufacture)	R. L. Wickremasinghe, BSc (Cey), BSc (Lond), PhD (Sheff), FRIC
Research Assistants	*R. R. Selvendran, BSc (Cey)
	G. R. Roberts, BSc (Cey)
Senior Technical Assistant	B. P. M. Perera
Assistants	K. Sivapalan, BSc (Cey)
	V. Fernando
	K. P. W. C. Perera, BSc (Cey)
	M. T. Subramanium, BSc (Cey)
Technology	
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Research Assistant	Vacant
Assistants	L. S. Weragoda
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	C. Kandappah, BSc (Cey)
	S. Samarasingham
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Assistant	K. Seevaratnam
Advisory Service (St Coombs)	
Chief Advisory Officer	C. B. Foster-Barham, MA (Cantab)
Research Assistants	*D. T. Wettasinghe, BSc (Cey)
	L. M. de W. Tillekeratne, BSc (Cey), MEd (Calif), (Dist Adv Officer, Uva)
	R. K. Nathaniel, BSc (Poona)
Assistant	D. N. R. Wijewardene
Photographer	D. J. M. Hettiarachi
St Coombs Estate	
Superintendent	J. G. G. Tennekoon
Tea Maker	Vacant
Apothecary	S. P. de Silva
Office Staff	P. E. de Silva
	M. R. K. Gabriel
	H. C. Wickramasinghe
St Joachim Estate	
Superintendent	G. S. Muttetuwegama
Office Staff	G. L. A. Thomas
Engineering	
Factor	O. J. Fernando
Works Clerk	R. A. Daniel
Storekeeper	I. P. Dissanayake
Electrical Foreman	W. R. Solomon
Mechanics	D. A. S. Opatha
	K. S. Vadivelu
Administration	
Chief Administrative Officer	G. M. Sparkes, BA (Cey)
Personal Assistant to Director	A. C. Perera
Assistant Administrative Officer	P. Pathmanathan, BSc (Cey), ACA
Librarian	D. J. S. de Silva, BSc (Punjab)
Assistant Secretary	C. Kirthiratne, FCCS (Lond)
Accounting Assistant	A. H. B. Dias
Stenographers	F. G. de Sielvie
	G. A. S. Gunasinghe
	P. W. Uduwawala
	S. A. L. H. Fernando
	S. D. J. J. Vitharnepathirana
	N. Peiris
Accounts Clerks	W. J. Samuel
	M. B. Palies
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	T. R. B. Sally
	K. D. B. H. Abeygunawardena
	G. A. K. P. de Silva
	S. Kulasabanathan
	H. Attanayake
	N. Sachithanathan
Records Clerk	J. P. J. E. Navaratne
Filing Clerk (Advisory)	K. L. D. Alwis
Library Assistant	D. S. Jayasekera
Clerk/Typists	V. Kodagoda
	J. N. Apasinha
	D. W. Bartholomeusz
	S. B. Wettewe
Translator/Instructor	C. M. Fernando, BA (Cey)

Visiting Agents

St Coombs—P. R. U. Easteal

St Joachim—J. W. Craig

*Working overseas

CONTENTS

REPORT OF THE DIRECTOR FOR 1964

A. W. R. Joachim, OBE, BSc, PhD, FRIC, Dip Agric

General

Two events which highlighted the activities of the Institute during the year under review were the conference in January—which on this occasion was held after three years—and the completion of the Low country Station and factory on St Joachim Estate by the end of the year.

The conference was held on the 23rd and 24th of January and was opened by the Hon Felix R. Dias Bandaranaike, Minister of Agriculture Food and Fisheries. Dr F. R. Tubbs, Chairman of the Scientific Advisory Committee in the UK was the chief guest. The other guests from overseas were : Mr S. K. Dutta, Chief Advisory Officer, Tocklai, Mr K. A. Hassan, Chief Scientific Officer, Pakistan Tea Research Station, Mr C. S. Venkata Ram, Plant Pathologist, UPASI and Dr M. T. Hutchinson, former Nematologist. Over 450 people attended the conference which, to judge from letters received, was much appreciated by the planting community in respect of both its organization and the technical programme.

As regards the Low country Station, it is with satisfaction that we record the completion of the entire building programme of the project within a period of two years. The laboratory and a number of staff quarters were completed and occupied in July and the factory and the remainder of the quarters by the end of the year. Besides the laboratory and factory, 28 residential units for the staff of the research and estate sections have been constructed on this station. Thanks are due to Mr R. Kahawita of Messrs Billimoria de Silva Peiris & Panditharatne, our architects, for his noteworthy efforts in the planning of the station and the designing of the laboratory and staff quarters. With the exception of the Technology staff, the full complement of research, advisory and estate staff are now in residence on the station.

The work on the factory, which was constructed by Messrs Walker Sons & Co Ltd and the installation of the necessary machinery which was done by various engineering firms, were both completed by the middle of December. The thanks of the Institute are due to the Low country Committee which spared no pains to ensure that all matters connected with the establishment of the station and the construction of the factory were done with as little cost and as speedily as possible. The former Technologist of the Institute, Mr E. L. Keegel, and his staff merit commendation for their part in the designing of the factory and the selection of the equipment and machinery for it. The factory includes a special technological laboratory which the Committee have named after Mr Keegel for the valuable services rendered by him to the industry in general and in connection with this factory, in particular. Messrs Walker Sons & Co Ltd did everything possible to speed up the construction of the factory and to ensure a high standard of work. A special word of thanks is accorded to them for their efforts.

Finally, special mention must be made of the dedicated service and constant endeavour in the cause of this project which Dr L. H. Fernando, Low-country Scientific Officer, and Mr C. Andrews, Superintendent of St Joachim Estate, gave to it. The station was to have been opened officially by the Hon'ble Minister of Agriculture in the latter half of December, but owing to unavoidable circumstances the function was postponed for sometime early next year. The factory will, however, begin to operate on January 1st, 1965.

An event of considerable importance to the Institute was the appointment of Dr E. M. Chenery, Director of the East-African Tea Research Institute, as the new Director of the Institute. Dr Chenery assumed duties on December 31st.

Another matter that needs special mention is the extension of the USA Department of Agriculture aid to the Institute for work on the meadow eelworm project. This was started in 1962 and was to have terminated at the beginning of 1964. In view, however, of the useful results obtained during the period, the authorities of the US Department of Agriculture agreed to extend the aid for a further period of two years, subject to the approval of the Ceylon Government. The thanks of the Board and of the Institute are due to the USA Department of Agriculture for their assistance and generous grant towards this worthwhile project.

Under the terms of the will of the late Mr E. J. Starey, a bequest of a sum of about £400 was made to the Institute. We place on record our appreciation of the generous thought which inspired the grant of this bequest by the late Mr Starey. It is proposed to utilize it for the purchase of some valuable books on tea for the library.

A feature of interest introduced during the year to which reference should be made is the holding of staff colloquia on subjects relating to the current work of the respective divisions. These were organised by Dr A. Kerr, Adviser in Plant Pathology and Nematology. 4 such meetings were held. The number of Board and Committee meetings held during the year was exceptionally high, being no less than 55. These were mainly connected with buildings and low country station matters. In addition, meetings of the Tea Subsidy Board, the PA General Committee and District Planters' Associations were attended.

From the point of view of tea production and marketing it is gratifying to the Institute to note that crop yields in most tea districts continue to be maintained at high levels. But because of the unsatisfactory distribution of rainfall during the year in many tea districts, crops fell slightly (just over one per cent on the average). In the latter half of the year prices of low-country teas dropped very appreciably because of the temporary dislocation of some of our traditional markets in the Middle East. With the entry of Iraq into the market again in the month of December, the prices of these teas rose to normal. The Institute did everything possible to collaborate with the Planters' Association of Ceylon in regard to representations to Government on the question of the import of fertilizers and agrochemicals, in order to ensure an uninterrupted supply of these essential materials for the tea industry.

The list of staff changes during the year is attached.

Visitors and Visits

Among the visitors to the Institute during the year were the following : The Hon Felix R. Dias Bandaranaike, Minister of Agriculture, Food & Fisheries, Sir Michael Walker, High Commissioner for the UK in Ceylon, Mr Enver Murad, High Commissioner for Pakistan, Dr A. D. Ayres of the USA Department of Agriculture and Mr C. Cope Famous of the USA Embassy New Delhi, Members of the British Parliamentary Delegation, Dr Cuthbertson, British Association Delegate to the Ceylon Association of Science, Dr H. R. Ambler, Scientific Adviser to the UK High Commission in India, Mr W. H. W. Coultas, Colombo Plan Tea Expert, and Dr F. N. Wright, Director, Tropical Stored Products Centre, London.

Mr H. W. Barlow, Head of the Plant Physiology Division of the East Malling Research Station visited the Institute during February/March to advise on the scope and functions of the Plant Physiology Division. Dr Barlow's report has been of considerable assistance in the formulation of a programme of work for this Division, vis-a-vis the Agronomy and Plant Propagation Divisions.

Mr J. E. Cranham, Entomologist, visited the South Indian and Tocklai Tea Experiment Stations during April to obtain a first-hand knowledge of tea pests and their control in these areas.

Mr W. T. Williams a Board Member, and Dr L. H. Fernando, Low-country Scientific Officer, attended the Annual Conference of the United Planters' Association of South India in September, as representatives of the institute.

Staff

The position in respect of staff was very satisfactory, the year having ended with almost the full complement of all grades. Dr R. L. Wickremasinghe joined the Institute as Biochemist in Tea Manufacture in the middle of June on the completion of his training in the UK. Dr D. Kirtisinghe returned to the Institute after post-graduate training in October and was appointed Acting Technologist.

The new post of Tea Taster was advertised in December.

I was on overseas leave for a period of two months from April 17th to June 17th during which time Mr J. A. H. Tolhurst, Deputy Director and Agricultural Chemist, acted as Director.

Four new Research Assistants were appointed to the divisions during the year for the subjects indicated against their names. These were : Messrs W. Bandaranaike (Agricultural Chemistry), S. Kandiah (Plant Physiology), Dr S. C. Wanigaratne (Agronomy, Low country), and Mr A. R. Sebastiampillai (Plant Breeding). A fifth, Mr W. Joseph, was appointed to the Technology Division as Research Assistant in Mechanical Engineering, but will only assume duties on January 1st, 1965. Mr S. Nagarajah returned from the USA in March after obtaining his MS degree in the University of California, and Mr R. R. Selvendran, Research Assistant in Biochemistry, left in October for post-graduate training at the Low Temperature Research Station, Cambridge, UK.

Buildings

Consequent on the change of architects during the course of the year our building programme received a setback. The work completed during the year include:

1 Extensions to two senior staff quarters
2 Extensions to two intermediate staff flats
3 Three junior staff quarters
4 New wing of four rooms for the junior staff hostel
5 Six minor staff quarters
6 Modifications to four existing minor staff quarters
7 Construction of a beef stall, store and quarters
8 Provision of furniture and furnishings for the following in the old Head Office building renovations to which were completed :

Six rooms for the Advisory division including a new room for the photography section
One room for the Agricultural Chemistry division
Two rooms for the Pathology division
Two rooms for the Statistics division
One room for the Physiology division
One room for the Library stores

9 Construction of a cold room for the Biochemistry division.

The following items of work were contracted out during the year and are nearing completion :

1 A two-storeyed building for soil sterilization bins and field recorders rooms
2 Chromatography room for the Biochemistry division
3 Three minor staff quarters.

Designs for the following have been finalised and tenders called for and contracts assigned. Work will commence early in 1965.

1 One two-storeyed senior quarters
2 Two split-level blocks for four junior staff quarters
3 A two-storeyed building for the engineering stores and offices
4 The conversion of the old caddy building to junior staff quarters.

Considerable improvements were made to the roads of the Institute during the year. A few new roads and road connections were constructed.

An augmentation of the water supply of St Coombs was effected by the raising of the reservoir bund by 1½ feet.

Library and Publications

Satisfactory progress was made in regard to the general index to the Tea Quarterly and it is hoped to release this publication before the middle of next year. The preparation of the bibliography to the literature on tea in relation to its agronomy, botany, breeding and selection, and diseases and pests is under way, and it may be possible to publish this in 1965. The total number of new books received during the year was 207. 12 new periodicals were subscribed to. The following publications were issued during the year :

1 Annual Report 1962—Parts I & II
2 Annual Report 1963—Part II
3 Tea Quarterly—Volume 35, Parts I -IV
4 Monograph No. 5—One Day Course in Tea Manufacture.

Sales of this monograph, apart from those distributed free to estates, agency houses etc have been quite good.

The number on the free mailing list for Institute's publications was increased by 68 during the year, making up the total to 1670.

Outlying Stations

Reference has already been made to the development of the Low country station on St Joachim estate, Ratnapura. The clonal testing stations at Kottawa in the Galle District, Hantane in the Kandy District and Passara in Uva have all reported good progress during the year. A review of the scope and functions of these stations has been made, but a decision on future policy in regard thereto has been deferred for consideration by my successor.

The Kottawa station has made very striking advances. A full programme of experimental work has been laid down on the 22 acres developed and a good revenue is now being obtained from the sale of cuttings and green leaf from the unit. A pilot clonal manufacturing factory is under construction.

After a number of efforts to find a sub-station typical of the dry tea areas of Uva, a suitable block of land has been found at Ury Group, Passara. Work on the development of this station will start as soon as arrangements for the purchase of an extent of land not exceeding 150 acres, are completed.

Negotiations have taken place during the year with the Hantane Investments Tea Co for the purchase of about 50 acres of land inclusive of the present sub-station, in order to ensure continuity of policy and justify expenditure on a comprehensive programme of development and extension work. This matter will, however, be reconsidered in the light of the final decision made on the policy regarding these sub-stations.

St Coombs and St Joachim Estates

Despite unfavourable weather conditions, yields of crops at St Coombs will be in the region of 1425 lbs per acre, only slightly less than that obtained in 1963. Prices for St Coombs teas have, however, improved in 1964, the average increase being of the order of 15 cents per lb. A number of improvements were effected to the factory and these have no doubt contributed in some measure to the higher prices obtained.

The yield per acre on St Joachim estate also dropped by a few pounds because of the unsatisfactory rainfall distribution even in the low country. The prices of green leaf were also poor during the latter part of the year because of the market conditions referred to in a previous paragraph. The agricultural condition of the estate is, however, very satisfactory. With the commencement of manufacture in St Joachim factory from January 1965, a profit on the working of the estate could be expected for the first time next year.

Advisory Work

The number of advisory letters received showed an increase and so did the number of visits made to estates for such purposes. Among new activities mention should be made of the holding of symposia on vegetative propagation under the auspices of the Planters' Associations of Passara, Badulla, Ratnapura and Kandy respectively. The new Uva Advisory District established last year has fully justified its existence, to judge from the number of activities it has embarked on and favourable comments received. A series of extension experiments has been started on a number of estates and some useful results are already forthcoming. The establishment of a low country division was delayed owing to lack of staff, but in December last year an experienced officer was appointed to this area.

Research Work

The reports of Research divisions will furnish details of the work done on matters coming within their scope. All that is necessary, therefore, is to draw attention to any interesting results or features which have emerged.

Agricultural Chemistry Division

Results from some of the comprehensive fertilizier trials established at different centres have been forthcoming. The St Coombs trials show a good response, in spite of generally unfavourable weather, to levels of nitrogen higher than would usually be considered in practice. The response to potash increases as the cycle progresses in the low jat trials at St Coombs, particularly as nitrogen is increased. On high yielding tea the response to zinc up to 20 lb zinc sulphate per acre per annum is good. The trial to study the effects of nitrogen applications before and after pruning shows that at the high level of nitrogen, an application three months before pruning influences crop yield but not tipping weights. A large number of new fertilizier trials was started especially on nursery and young tea.

Agronomy Division

The work of this division has been mainly concerned with the study of the absorption of nutrients by tea both in the plant house and on a field scale. Arising from some of these studies certain interesting features applicable to the experimental conditions have been noted. One such is the question of the amount of the fertilizer to be applied to young tea at any one time and the method of application. The frequency of application is therefore of importance. Broadcasting of fertilizers appears to be preferable to placement in a ring around the plant or in the planting hole.

Of the nutrients absorbed by tea, nitrogen, calcium, potassium, magnesium, aluminium and phosphorus were taken up in the order indicated. A start has been made with the investigation of the part played by aluminium in tea. The effects of soil erosion on tea land have also been studied.

Low Country Station

The results of the fertilizier experiments on VP and seedling tea at Palmgarden and Endane estates respectively, confirm those obtained in the previous cycle. At Endane no responses were obtained to nitrogen phosphorus potassium magnesium and zinc on seedling tea in the first year of the cycle. Dieldrex increased yields by 7 per cent. At Palmgarden increases were obtained on VP tea with nitrogen in the second and third but not in the first six months of the cycle. The highest yield was obtained with the highest frequency of application at the highest nitrogen level.

A yield response to 10 lb zinc sulphate per acre was observed at the end of the first year on seedling tea at St Joachim estate. Other agronomic experiments in progress on the station are designed to test : (1) the effects and interactions of the major nutrients on seedling tea under varying stands of shade ; (2) the efficacy of herbicides on such tea. Results so far obtained indicate that it is advisable to use these chemicals at about half the levels now recommended by suppliers ; (3) the relative efficacy of various legumes for soil rehabilitation; (4) the comparative advantages and disadvantages of different pruning systems and methods of bringing into bearing ; (5) the merits of selected clones and biclonal seedlings under typical low country conditions.

A comprehensive series of clonal and other trials is also being conducted at the Kottawa sub-station in the Galle District.

Plant Physiology

This division now concerns itself mainly with the study of factors related to the growth of the tea plant. This has been attempted from three angles—the effect of various cultural practices on dry matter production, the effect of pruning treatments on cropping levels, and the influence of various manipulative treatments on the growth of individual shoots. Studies have also proceeded on photosynthesis and fluctuation of carbohydrate reserves in tea roots in relation to cultural operations like pruning. Long term trials on shade effects have been continued, and also those on the problem of dormancy in the tea bush.

Plant Propagation

Nursery trials to compare the rooting of clones in different types of soils indicated that Guatemala soil and jungle soil gave the best results. The 1961 clonal proving trials have completed one year's plucking and the results indicated that the TRI clones are amongst the highest yielders. Investigations on the performance of biclonal seedlings as compared with open pollinated clonal seedlings and those from commercial seed gardens are proceeding.

Entomology

Entomological work continued on Shot-hole Borer, Tortrix and mites. A survey showed that the incidence of Tortrix outbreaks was naturally high in up country districts, including Dimbulla and Dickoya, in the early months of the year. In some districts where dieldrin spraying was fairly intensive (Pusselawa and Badulla), the Tortrix side effect was aggravated and outbreaks on unsprayed tea were serious. Experience of the control of Shot-hole Borer by dieldrin spraying on a larger scale in 1963-64, has shown that the value of the yield increases resulting from control usually far outweighs any first year losses from Tortrix. However, Tortrix has become more troublesome locally, and this focusses interest on the value of the possible alternative insecticides, aldrin and Telodrin, which have less effect on the parasite of tea Tortrix. Extensive trials on the use of these insecticides are in progress and results are so far promising.

Plant Pathology

Preliminary trials indicated that nickel chloride is as effective as copper fungicides in controlling blister blight. The soil fumigant DD injected at 6 inches at a dosage of 2000 lb per acre continues to give excellent control of the *Poria* root disease. Other fumigants are being tried out. There is strong evidence to indicate that clones vary in their susceptibility to *Poria*.

Inoculation experiments have shown that collar and branch canker is caused by *Phomopsis theae* and not by *Leptothyrium theae*. Field experiments have been initiated to determine the relative susceptibility of various clones to the disease and the environmental factors which influence susceptibility.

Nematology

Three more clones, M 146, M 116 and DK 1, have shown significant resistance to the meadow nematode. The beneficial effect of marigold, used for the control of this nematode, are still being noted. Nematode numbers fall rapidly during the rehabilitation of nematode infected soil with Guatemala grass, but nematodes can survive for more than 18 months on any large tea roots not removed at uprooting.

Pot experiments indicate that nematodes from different estates differ in virulence and that the building up of nematode numbers is much faster in some soils than in others.

Biochemistry

Studies on the biochemical basis of quality in tea were made by comparing TRI clones 740 and 777 with respect to chemical constituents during the wet and dry seasons. Significant differences were found in some important constituents like flavanols and polyphenolase activity. A theory of withering was formulated and an exposition thereon was published in the September issue of the Tea Quarterly. Useful results have also been obtained from studies on the nitrogen and organic acid metabolism of the tea leaf and of carbohydrates in tea shoots. An interesting discovery of biochemical interest is the finding that polyphenol oxidase is a soluble enzyme.

Biochemistry (Tea Manufacture)

This division was inaugurated in July 1964 as a separate entity. Investigations have so far been made on the carotenoids of tea and the formation of keto-acids during manufacture. Estimations of the polyphenols of tea in different clones have also been undertaken. The relation, if any, of these chemical constituents to tea quality should emerge with the extension of these studies.

Technology

Further investigations have been carried out on trough withering, rotorvane manufacture and fermentation. It was established that normal periods of fermentation given to orthodox teas were equally suited to rotorvane teas. A mixed rotorvane orthodox rolling programme produced teas superior to those of orthodox rolling. A comparison of teas from trough withered leaf with those of leaf withered on conventional tats showed in a preliminary trial, that no significant differences in respect of tasters valuation are observed. A preliminary investigation carried out to test the suitability of nylon mesh against PVC (polyvinyl chloride) sheets and a standard concrete table for fermenting dhools, showed no significant difference between treatments.

Statistics

A course in elementary statistics of about three months duration was given to officers of the Junior and Intermediate grades. Classes were held weekly and were optional. The division was responsible for advice on special experimental designs to meet varied conditions and the analysis of the data of these trials.

A series of multiple regression studies were made on data obtained from experiments on Shot-hole Borer suction traps and on Shot-hole Borer experimental data from 6 estates in relation to temperature, rainfall, wind, and other factors.

Acknowledgements

The thanks of the Institute are expressed to the Planting Associations, Agency Houses, Managers and Superintendents of estates for the cooperation they have given us in the conduct of our experimental programme.

I must conclude by expressing my personal thanks to every member of the staff for the loyalty and cooperation extended to me during my period of office as Director of the Institute.

STAFF CHANGES 1964

APPOINTMENTS

Senior Staff

Dr R. L. Wickremasinghe Biochemist from 17th June
P. Kanapathipillai Statistician from 26th October

Intermediate

W. M. Bandaranaike Research Assistant (Agricultural Chemistry) from 1st January
S. Kandiah Research Assistant (Plant Physiology)from 1st January
Dr S. C. Wanigaratne Research Officer, Low country Station from 6th May
A. R. Sebastianpillai Research Assistant (Plant Breeding) from 4th September

Junior Staff

M. Sikurajapathy Technical Assistant (Agronomy Division) from 1st January
K. Thirugnanasundaram Technical Assistant (Entomology Division) Hantane from 15th January
S. Krishnapillai Technical Assistant (Physiology Division) from 1st January
D. W. Bartholomeusz Clerk/Typist from 15th April
S. B. Wettewa Clerk/Typist from 4th May
S. A. L. H. Fernando Stenographer from 1st June
K. P. Goonewardena Clerk (Low Country Station) 20th April
H. Attanayake Accounts Clerk from 2nd May
N. Satchithananthan Accounts Clerk from 4th May
N. Yogaratnam Technical Assistant (Low Country Station) from 4th May
U. P. de S. Waidyanatha Technical Assistant (Low Country Station) from 4th May
D. N. R. Wijewardena Technical Assistant (Advisory Division) from 1st June
L. K. Karunatileke Establishment Clerk from 1st July
S. D. Vitharnapathirana Stenographer from 3rd July
M. T. Subramaniam Technical Assistant (Biochemistry) from 15th October
K. P. W. C. Perera Technical Assistant (Biochemistry) from 1st September
T. Kularatne Technical Assistant (Agri-Chemistry) from 15th September
N. Peries Stenographer from 2nd November
C. M. F. Fernando Translator/Instructor from 12th December

Overseas Training

Dr R. L. Wickremasinghe returned after his special training at the Low Temperature Research Station, Cambridge on 17th June, 1964.
Dr D. Kirtisinghe returned after his post-graduate training at the Imperial College of Science & Technology on 16th October, 1964.
Mr S. Nagarajah returned from USA after obtaining his MS at the University of California on 20th March, 1964.

Mr R. R. Selvendran Research Assistant (Biochemistry) left for the UK on a scholarship for post-graduate training at the Low Temperature Research Station on 4th October, 1964.

Leave

Dr A. W. R. Joachim Director, was on leave in the UK from 17th April to 17th June

Acting Appointment

Mr J. Tolhurst acted as Director during absence of Dr Joachim from 17th April to 17th June 1964.

Overseas Visits

Mr J. E. Cranham visited the South Indian and Toklai Experimental Stations from 17th April to 4th May 1964.

Mr W. T. Williams and Dr L. H. Fernando attended the United Planters' Association of South India, Annual Conference from 28-8-64 to 6-9-64 as representatives of the Ceylon Tea Industry.

Resignations

Mr L. K. Karunatileke Establishment Clerk from 3rd October.

Deaths

Mr T. S. Nathan Technical Assistant (Biochemistry) died on 8th May 1964
Mr N. D. Lewis Stenographer died on 26th July 1964.

REPORT OF THE AGRICULTURAL CHEMIST

FOR 1964

J. A. H. Tolhurst, BSc

General

The Head of the Division continued duties as Deputy Director, and was also required to be Acting Director for two months. Mr Bandaranaike, recently appointed as one of the Research Officers, resigned in December to take up a teaching post at the University.

The team of Field Recorders also suffered loss. Mr S. Samarasingham, who was the first member of the team, created in 1958, transferred to Technology Division for medical reasons. Mr S. K. Govindaswamy resigned in December to take up a planting post. Grateful acknowledgement is made to all these officers for their contributions to the Division. Mr T. Kularatne was appointed in October as Technical Assistant.

Field Experiments

1964 was an unusually dry year for St Coombs, a notable feature being the number of rainless periods of 7 days or longer, often accompanied by cold dry wind. There were 12 such periods as compared with 7 in 1963. The South-West monsoon was late in breaking and the first 6 months of the year were quite exceptionally dry. At no season were "rush crops" experienced for more than two or three plucking rounds. Results from the experiments were naturally influenced by these conditions and some interesting points emerged.

When, later in the year, it became evident that we should be faced with the prospect of losing many or all of our team of Recorders to the tea industry, the programme of trials was curtailed in some respects. Changes in estate policy regarding fertilizer usage, also meant that the direction of the newer trials had to be reviewed. In order to allow for all eventualities, plans were made to increase nursery material, so that at least the division could bridge a transition period with more detailed studies in the nursery or young tea fertilizer trials which are an integral part of our normal programme.

Acknowledgement is gratefully made to various colleagues, especially the Statistician, for assistance.

Reference to earlier Annual Reports should be made for details of experimental design.

1 *N P K Experiment: No 3 Field St Coombs*

The exposure of most of the plots on hilltops meant that growth suffered badly in the drought. Tortrix attack was more severe than usual and played a part in bringing about poor yield levels. Response to nitrogen was a notable feature throughout periods of low yield, and a similar yield response to the highest level of potash was also noted. Table I shows the summary of the N and K effects for the present, 11th, pruning cycle to the end of 1964. Yields are expressed as lb fresh weight per plot for the whole 32 months. All zero-phosphate treatments are omitted from this analysis.

TABLE I—*Yield response to N and K, No 3 Field NPK Experiment, St Coombs. 11th pruning cycle: mean yields as lb fresh weight per plot per 32 months*

N 1	N 2	N 3	LSD (P=0.05)
(120 lb)	(150 lb)	(180 lb)	
659	744	857	91
K 1	K 2	K 3	
438	872	950	91

It is clear that a yield response to N in excess of the highest level, 180 lb N, could be expected, especially as the tea has so far tended to increase its response as the cycle progresses. A further selection of yields for the calendar year, 1964, omitting zero-phosphate and zero-potash plots and approximating yields to a made tea per acre equivalent, will show that nitrogen is being used with surprising efficiency.

N 1	N 2	N 3
971	1258	1466

These results, which do not lend themselves readily to statistical analysis, suggest a response of about 8 lb of made tea to every extra 1 lb of N over the range 120 to 180 lb N per annum, with a slight falling off at the higher levels of N. Bearing in mind the very poor jat of tea in these plots and limitations undoubtedly imposed by their situation, these trends might be offered as a guide to estate fertilizer programmes. Results from an experiment in No 9 Field, on a better jat of tea, will be seen to support the same trend of ideas.

The adverse effects of the lowest, zero, level of potash are as expected, but bush vigour does not appear to have deteriorated as rapidly as was feared when the special pruning programme was started in 1959. It is on the yield differences between the two higher levels, 60 and 90 lb K_2O, that interest now focuses. Omission of zero-phosphate plots from the analysis given in Table I was done because it was clear that these were limiting response to N and K. As a result the effect of errors in the analysis was increased. It remains to be seen if future yield trends will permit a statistically significant potash response to be obtained from the higher levels in this experiment. There would seem to be urgent need to put this point to the test in a more precise experiment, especially as there are suggestions of an N × K interaction. This can be seen from the yields given in Table 2 over the same period and expressed as lb fresh weight per plot.

TABLE 2—*Yield responses to different nitrogen and potash levels*

	N 1	N 2	N 3
K 1	437	415	462
K 2	751	875	991
K 3	789	942	1119

The depression in yield imposed by 60 lb P_2O_5, compared to 30 lb, was negligible and no yield response could be attributed to the magnesium treatments. Both these nutrients are now being studied with more precision in

Experiment No 2 (below). There is no doubt that the appearance of the foliage in the magnesium sprayed blocks is superior to the remainder, but the overall estimate of magnesium deficiency, by observation of symptoms, is that it is still very mild. This may be noted in connection with the suggestion of response to the recently increased potash levels, and the picture may well change in time.

Leaf analyses from this experiment and also No 2 have been done for some time, adopting simple sampling and analytical techniques. Sampling, at various seasons and in relation to fertilizer application dates, will be continued but selected results are quoted here (Table 3) to illustrate a problem which has been met throughout. Flush is occasionally sampled, but mature leaf samplings show the same trends.

TABLE 3—*Nitrogen content of mature leaf from fertilizer trials on St Coombs: as % N of dry matter*

No. 9 Field : lb N acre	75	150	225	LSD (P=0.05)
Aug '63	3.48	3.61	3.73	0.15
Feb '64	3.47	3.54	3.63	0.14
No 3 Field : lb N acre	120	150	180	
Feb '64	3.30	3.33	3.47	0.15

It is of interest to note that in spite of marked yield response to N levels, the nitrogen content of the mature leaf should show so little variation, which only just reaches significance between the extreme fertilizer doses. It is hoped to be able to use these and other plots to develop techniques based on a fundamental approach. At present only extreme deficiency or excess of N could be assessed, and it is obviously unsatisfactory that the needs or potential response of the bush over such a vital range of fertilizer levels defy solution by common techniques. Success is likely to depend more on a study of nitrogen fractions in the leaf than on variations in field sampling methods, which offer little flexibility.

2 *Foliar Spraying Experiment: No 9 Field St Coombs*

These plots, being in a more sheltered locality than the above experiment, suffered less from drought. Yields for the nitrogen treatments for the first two years ending October 1964, were as shown below. They are approximated to lb dry weight per acre, eighteen plots contributing to each treatment.

	N 1 (75 lb)	N 2 (150 lb)	N 3 (225 lb)
1st year	1050	1150	1250
2nd year	1160	1500	1840

It was decided to raise the nitrogen levels by one third for the third year, bringing the treatments to 100, 200 and 300 lb N per acre. Sulphate of ammonia will continue to be used, and as the pH of the top 6″ of soil shows little variation from 4.1, these plots should eventually be useful for investigating the effects of high levels of this fertilizer on certain soil conditions. It is hoped that with the new levels of N the yield response curve will depart from linearity and provide information on the economic upper limit of N for this type of tea ; an average jat. It is a matter of considerable interest that, equally over the whole range 75 to 225 lb N per annum, a yield response of about 4½ lb of made tea was obtained in the second year to each additional 1 lb of N. During drier

periods this figure fell but the differences between the three N levels were still appreciable. Assessment of value of N in relation to season would really require a separate series of experiments, but some information will eventually be culled from this and other experiments as time progresses.

Response to zinc fell off markedly during poor growing weather in the monsoon months, in contrast to the maintenance of a response to N. This had been noted in earlier zinc spraying experiments and appears to be due to the mode of action of zinc (as a foliar spray) rather than to the removal of zinc sulphate by rain. Yield responses were again seen, once climatic conditions improved, even though no further zinc sprays had been applied in the meantime. The dry weight yields, lb per acre, for the zinc treatments (also for 18 plots) were :

	Z 1	Z 2	Z 3
2nd year	1440	1510	1540

Subsequent levels will remain at 0, 10 and 20 lb zinc sulphate, but as no differences resulted from varying the frequency of application this third treatment has now been stopped. The most recent yield records show a response to zinc more promising than is indicated by the quoted figures. As the third level now represents over 60 lb zinc sulphate per acre over a three year period, and as deficiency symptoms still reappear in a mild form, this seems to point to the need to intensify the search for the reasons for the onset and persistence of the deficiency.

The general fall in yield in the monsoon caused some concern, and it was suspected that a maintenance level of 30 lb K_2O per annum was too low for the yield potential. Overall K_2O was raised to 90 lb per acre, and at the same time, early September, a phosphate treatment was introduced in place of the frequency-of-zinc-spraying treatment. Saphosphosphate is now included to give P_2O_5 levels of 0, 25 and 75 lb per acre. To-date, no phosphate effects have been noted, although yields over this period rose sharply.

Later in the year each of the 54 plots was split to receive epsom salts spray treatment, at levels of 0 and 40 lb per acre per annum, in 4 applications.

Apart from the direct effects of P and Mg, the experiment will give information on relations between zinc and these nutrients. It is clear that zinc deficiency has not been induced by the high levels of sulphate of ammonia, and attention then naturally turns to other fertilizers and nutrients. The tea industry may, in the short term, gain useful information from the effect of adding phosphate, it being remembered that none had been applied for the first two years of this experiment. A brief report on this point will be issued as soon as it is deemed safe to do so.

3 *Type-of-zinc Experiment: No 12 Field St Coombs*

After a short uniformity period, treatments were started in May to compare the efficiency of zinc oxide and sulphate, with or without the addition of Perenox (cuprous oxide) at the time of spraying. Zinc levels equivalent to 5 and 10 lb of the sulphate were applied in one spray, compared with a control. An additional spraying treatment involving two volumes of water was nullified by light rain at the time of spraying. This allowed us to ignore the treatment at a later date and to select one set of plots for study of residual effects. Three replicates are laid out, and adequate NPK is applied uniformly.

An early suggestion of response to zinc fell off during the unfavourable monsoon months, but has since reappeared. Treatment was repeated in October, leaving half the previously sprayed plots untreated. To-date there have been no differences between any of the zinc treatments, but it will be necessary to run the experiment into a season of higher yields before it could be safe to draw firm conclusions about the true value of the zinc response. Investigations by the Pathology Division into the fungicidal value of a zinc oxide-Perenox mixture should be read in this connection.

The 51 plots cover a ridge extending for about 400 feet from very near the top of the No 12—No 13 Field hill on St Coombs, to the top of a small saddle half way down the East-facing slope. It has been interesting to note that plots near the top of the unit tend to yield more highly than those near the saddle. Further investigation of soil conditions and climatic differences might be of value to explain this unexpected fact, which is evident even in dry weather. All shade trees had been ring-barked early in the year and could have contributed very little to any yield trends.

4 *Type-of-Nitrogen Experiment: No 9 Field St Coombs*

Recovery from the 1963 (October) pruning was slow, possibly aggravated by the prolonged drought at a critical stage. The collar pruned blocks were not so handicapped as might have been expected and have subsequently made good growth following early tipping and normal plucking. Fertilizer application was delayed by the drought and the first year of this cycle received only two thirds of the full allocation of 150 and 300 lb N per annum. Import restrictions led to the abandonment of the granular fertilizer after the first application. Urea has been put in its place while negotiations are in hand for import of a form of ammonium nitrate.

To-date, no differences in yield have been noted from the types of N. The first-year yields, as lb dry weight per acre, were as follows :

	N 1 (100 lb)	N 2 (200 lb)
Cut-across prune	960	1160
Collar prune	216	226

Late in the year, yields from the collar pruned plots were rapidly approaching those from the remainder, and bush vigour was encouraging.

5 *Frequency-Nitrogen Experiment: No 13 Field St Coombs*

Nitrogen treatments, 120 and 240 lb N per annum, applied 2, 3 or 4 times each year were introduced in September. The only point to report here is that once again the recovery from pruning has been remarkably poor. Development of side branches is still poor at 15 months. Experience gained from other experiments, some in the same field, strongly suggests that this area was planted with a peculiar type of seed and it must be hoped that results will not be jeopardised by such abnormality.

6 *Nitrogen-Timing Experiment: No 13 Field St Coombs*

Previously reported as "Manure-Timing", this experiment has already shown an effect which may prove to be of general importance.

The uniformity period included an overall fertilizer application of 22 lb N per acre 6 months before pruning, and thereafter the treatments comprised :

Nitrogen 3 months before pruning at 40 and 80 lb N
Nitrogen after pruning at 40, 60, 80 lb N
Post-pruning application at either 2 or 4 months

The twelve treatment combinations, replicated four times, were laid out with three extra plots in each of the four blocks. These plots had no N three months before pruning but received the above three N levels 2 months after pruning.

Results are here quoted subject to statistical analysis, which will be done on completion of the present phase of investigation.

Pre-pruning N applications, 40 and 80 lb, were associated with yields of 400 and 450 lb dry weight per acre over the three months before pruning, while the zero-N plots yielded 320 lb. These effects did not persist after pruning in the tipping weights.

Post-pruning applications of N have so far shown no response in terms of tipping weight, percentage N in the tip, or pluck weights over a few rounds. Growth at each period of application was good, and following a cut-across prune the frames were large and healthy. Nitrogen contents of the tip, 3.6% N, were not so high that it could be suggested that the bushes were saturated with nitrogen. Much higher values have been recorded in the past. If the reason for the lack of response could not be provided by any peculiarity of bush condition, it may well be found in the method of fertilizer application.

By coincidence, each post-pruning application was made when the heavy leaf mulch was moistened just enough to dissolve the sulphate of ammonia and to allow it to recrystallise on the surface of the leaves. On each occasion a dry period followed, and it is presumed that the fertilizer was absorbed by the mulch with very little reaching the soil. There are various fates which absorbed nitrogen could suffer, and a study of these reactions would need to be done under closely controlled laboratory conditions. The question of envelope-forking obviously would arise, but even the inclusion of pockets of nitrogen-saturated mulch in the soil might not be sufficient safeguard against some methods of loss of nitrogen. ("Nitrogen" is here used in the agricultural sense of the word and does not denote any one chemical form of the nutrient.) The agricultural implications of these suspicions are clear and it is hoped to be able to investigate the problem in detail.

7 *Nitrogen-Distribution Experiment: No 13 Field St Coombs*

A small experiment was laid down late in the year to study the effects of distributing a given dose of fertilizer either in alternate rows or in both rows at each application. A simple split-plot design, in fourfold replication, includes two levels of N, 120 and 240 lb per annum, and two fertilizer mixtures, T 700 and 750. These plots could also afford useful leaf and soil material for chemical investigations, and particular attention will be paid to the direct effect of the muriate of potash on the bush and to the indirect effects of sulphate of ammonia on soil conditions.

8 *Young-tea Experiments*

8.1. St Coombs Planting had been intended for April, but because of the drought and the temporary diversion of the Head of Division to administrative duties, it was decided to postpone planting until June. The unexpected continuation of dry and windy weather meant that when planting was finally attempted water supplies were minimal and one experiment (Clone TRI 2023

only) had to be abandoned. The 1964 series concentrated on studying whether certain fertilizers could safely be used in certain ways, and the adverse weather was in effect an advantage by increasing the possibility of damage to slowly developing plants. Clone 2023, even where sheltered by the other three clones, DT (Drayton) 1, CY (Tangakelle) 9 and TRI 2142, suffered badly from wind and will be replaced by TRI 2025 in future series.

Harvesting, by uprooting, started in November and some time will be needed to assess the detailed measurements and chemical analyses of the fractionated plants. A summary of trends will be given, subject to confirmation later. It is hoped that the very detailed fractionation will help in future work where perhaps destructive harvesting will not be possible. It is already clear that stem diameter, at some arbitrary height, is not only difficult to measure even by skilled personnel in the laboratory, but is also subject to serious error on certain clones with highly asymmetric stems. Maximum height of stem, which can be measured readily and quite precisely in the field, appears to be a useful internal index for free-growing DT 1 (a very upright plant in its younger stages) but is not so reliable for the readily branching 2142. Other relations peculiar to individual clones will no doubt emerge.

YT 1 Potassium metaphosphate at approximately ¼ and ½ ounce per planting hole appeared to be safe, whether mixed 2″ into the bottom of the hole or left in an unmixed layer. Roots from all four clones grew through the fertilizer, some of which remained undecomposed after 6 months. Compared with control plots, there is a suggestion that the leaf dry weight of 2023 was slightly increased and that of CY 9 decreased by both levels of metaphosphate. Root weight of CY 9 was not decreased. Chemical analysis of the total foliage showed more evidence of an effect, but enhanced uptake of potash and phosphate was rarely striking when compared with the control.

Further experiments are planned, but it seems safe to offer this fertilizer for estate trials. Mixing into several inches of soil at the bottom of the planting hole would be an advisable operation.

YT 4 Clone 2023 only was planted in a site removed from the first two experiments, and during the 6 months most plants were almost defoliated by wind on two occasions. Growth was very poor by normal standards and the results of this experiment are therefore of added interest.

Sulphate of ammonia was dibbled 1-2″ into the soil in a circle of 2-3″ radius at four levels, 0, 1/8, 3/8, 3/4 ounce per plant. One application was made shortly after planting, the second at 4 months. Harvesting was at 6 months. The fertilizer was worked into the loose-soil zone round the nursery core (polythene sleeves of 1¾ inch radius) and on each occasion an appreciable shower of rain followed. In spite of placement so close to the zones where newly developing roots would proliferate no symptoms of damage were visible at any time. Leaf dry weight showed an increase in proportion to the level of fertilizer. Root dry weight showed an increase up to the 3/8 ounce level, with a decrease below the maximum at the ¾ ounce level.

These results were so unexpected that a more detailed experiment is planned for 1965, on four clones. If normal, vigorous, growth can be obtained the supposition is that even higher levels of sulphate of ammonia might be safe, or even beneficial, under conditions pertaining to St Coombs.

YT 5 An experiment with a similar objective was done on Clones 2142 and CY 9 adjoining YT 4. Sulphate of ammonia and muriate of potash, each at three levels (including 0) were applied in solution to the bottom of the planting hole. All 9 treatment combinations were employed. The plants were put straight on to the saturated soil with no further mechanical mixing. No signs

of damage were recorded at any stage, although the treatments included levels as high as ¼ ounce sulphate of ammonia plus 1/8 ounce muriate of potash, and both clones had plentiful root development at the bottom of the nursery core which came into direct contact with the saturated soil.

8.2 St. Joachim

The experiment with Clone 2023 and mixtures based on T 200 suffered a number of casualties. Analysis of the results showed that deaths could not be related to treatments. This could partly have been due to a design with too low a replication, and partly because the treatments maintained the most probably damaging fertilizer (muriate of potash) at common levels. The attempt to simplify the investigation may thus have defeated its own object. It is hoped to extend the St Coombs investigations to St Joachim, and it is clear that a detailed approach to the problem of young tea fertilizer programmes is the most efficient in the long run. Soil and climatic variability must be of great importance in determining the value of some of the fertilizers and placements already listed, and we would not attempt to lean too heavily on results obtained only from St Coombs.

8.3 Gouravilla Estate, Upcot

A generous offer by Mr P. R. U. Easteal allowed us to lay down a fully fledged experiment under conditions which differ from St Coombs. Sulphate of ammonia at 0, 0.3 and 0.6 ounce per plant is compared with urea-formaldehyde at equivalent nitrogen levels. Placement was either in the planting hole or on the surface immediately after planting, with no mixing into the soil other than the considerable penetration of the sulphate of ammonia solution which was used when the soil was freshly dug and rough. A separate experiment was planted on each of two clones, Kenilworth 16/3 and T7 (Hope), and three blocks of each were sited on a steep gravelly slope with the remaining three blocks on a nearby area of gentle gradient and finer soil. Heavy rain in the week after planting probably distributed the sulphate of ammonia thoroughly in the loose soil. To-date all plants, which were vigorous and well developed, have grown well in the field with no signs of damage although a severe drought set in soon after planting in November.

Future experiments on young tea will at first concentrate on finding efficient ways of using maximum quantitites of different types of fertilizer, with emphasis on placement in the planting hole. Clones have often shown remarkable rates of development in the field, and it seems logical to approach this problem from the point of view of the possibility of using massive doses of fertilizers with the minimum of intricacy, and cost, in frequent applications. There should be little difficulty in achieving this with the range of types available and with considerable opportunity of a range of placements at planting. Nutrition of individual clones once they have passed the critical first year in the field will have to be studied on a different basis, and it is hoped to introduce such experiments before long.

8.4

Inspection of the fertilizer trial on young Clone 2023 at the Kottawa Sub-Station showed that several areas were retarded, presumably owing to wind effects. It was therefore considered unwise to try to assess the tipping weights in terms of the three types of nitrogenous fertilizer which had been superimposed on the blocks.

9 *Nursery Experiments: St Coombs*

The main experiment in 1964 tested potassium metaphosphate and dolomite, in combination at two levels, with or without admixture of sulphur in the dry state. Mixtures were applied in three ways: spread on the surface of the soil in the filled polythene sleeve; mixed into the top 2″; or mixed with the whole bulk of soil. Treatments were further sub-divided into application either 5 weeks or immediately before striking cuttings. Three experiments were laid down, on Clones DT 1, 2142 and 2024.

Some damage was recorded on the cutting leaf, but this did not appear later to have been of great importance. Two clones have been harvested to-date and the results are yet to be analysed. There are indications that the metaphosphate had a beneficial effect, and that damage occurred rather readily from the higher level of dolomite. Growth in general was good and the percentage of deaths was very low indeed. This experiment, by virtue of its design, could not offer a clear separation of the effects of fertilizer alkalinity and nutrient supply. A further series of experiments was therefore initiated to investigate nutrient effects.

Frequent observation of zinc deficiency symptoms in nurseries, regardless of soil type and techniques of management, led to the initiation of an experiment to elucidate the problem. It is suspected that the deficiency is being induced by excessive application of one or more fertilizers. A nursery on St Joachim with over 80 clones showed a wide variation in severity of the symptoms, even after a few zinc sulphate sprays, and two clones were selected for the experiment. Clone TRI 2026 appeared to be free from symptoms, while Clone D (Diyagama) was the most severely affected.

10 *Soil Organic Matter Investigations*

Although this work had to be interrupted by the loss of staff, particularly one of our Research Officers, comment on the aims and preliminary findings may be appropriate.

The Division's experiments now cover appreciable proportions of some topographical units on St Coombs and correlation of yield records with soil properties could be contemplated on a systematic, if long term, basis. The fate of organic matter in the soil is obviously of interest and routine sampling is in hand for all experiments. A start was made on the four experiments grouped on one hill in Fields 12 and 13. These sites are clearly variable with respect to factors such as wind, light, and subsoil drainage, and evaluation of effects of quantity and distribution of organic matter in the profile will have to be considered in conjunction with other factors.

The Frequency-Nitrogen Experiment was superimposed on 24 plots belonging to the former Phosphate-Type Experiment. During the earlier phase, 1947-1963, all plots were separated by an inter-row space which received no fertilizer. Preliminary sampling at the end of this phase showed that the organic matter in the 0-3″ soil layer was higher in the plots than in the adjacent buffer strips. The difference was very much less in the 3-6″ layer, but here also all but two of the 24 plot/buffer pairs showed a gain in the fertilized soil. Differences were not significant but, as shown in Table 4, are considered to be worthy of further investigation.

TABLE 4—*Organic matter as % C (Walkley and Black) in fertilized and unfertilized soil No 13 Field St Coombs*

Soil depth	Fertilized	Unfertilized
0–3″	5.30	4.25
3–6″	4.02	3.65

Other experiments lend themselves to similar studies and it is hoped to restart these very soon.

The Nitrogen-Timing Experiment runs from near the top of the Frequency-Nitrogen ridge, to the brow of the main hill. A total distance of 500 feet up the slope. For several years the soil in this area was thoroughly mixed in pits 18″ deep, extending eventually to the full length of the rows in most plots of the orginal Weeding Experiment. It was therefore surprising to find a rather uniform and high organic matter content (5-6% carbon in the 0-6″ layer) regardless of position on the slope. Plot yields from the new experiment during the uniformity period showed very little relation to situation; comment on yield trends in the nearby No 12 Field experiment (see above, 3) has already been made and these plots are also due for similar soil studies. Tea, as grown in most estates in Ceylon, could be expected to encourage an accumulation of organic matter by virtue of the good soil cover and minimum of soil disturbance. It should be remembered that accumulation, especially as it entails an immobilisation of nitrogen, need not necessarily be desirable indefinitely. Soils on St Coombs tend to contain respectable quantities of organic matter and may not benefit by an increase. Complementary studies under low country conditions would be needed to keep a balanced attitude to this problem.

Publications

TOLHURST, J. A. H. (1964) Observations on the progress of certain manurial trials on St Coombs. *Tea Quart.* **35:** 57-60.

TOLHURST, J. A. H. (1964) Pruning Clone TRI 2024; observations in the mid-country. *Tea Quart.* **35:** 174-175.

REPORT OF THE ADVISER IN PLANT PROPAGATION FOR 1964

A. V. Richards, BSc, MSc, Dip Agric, AICTA

1 General

1.1 Staff—Mr A. R. Sebastiampillai Post Graduate Scholar, was appointed Research Assistant in Plant Breeding from September 1964. Mr V. S. Kulasegeram Research Assistant, continued his postgraduate studies at Wye College, UK. Mr D. D. Kroon Technical Assistant in charge of VP work at the TRI sub-station Passara, was transferred to St Coombs on 1st November 1964. Mr H. B. Ratnayake continued to be in charge of the VP section at the TRI sub-station, Hantane.

1.2 Advisory—Advice on special problems relating to VP were given in collaboration with the Advisory division, and joint visits were made to a number of estates including some managed by the Ceylon State Plantations Corporation.

1.3 Symposia—Four Symposia on VP were held at Passara, Badulla, Ratnapura and Kandy on July 14, July 16, September 16 and December 4 1964 respectively. They were organised by the respective District Planters' Associations in consultation with the Advisory officers of the TRI, and were well attended. A field demonstration was also conducted at the symposium at St Joachim Estate, Ratnapura. It is proposed to have more symposia of this nature in other districts and thereby give an opportunity for mutual exchange of ideas between planters and the specialist and advisory staff of the TRI.

2 Nursery Trials

2.1 Nursery testing of clones (St Coombs, Hantane, Kottawa, Passara)

The fourth series of nursery tests which were originally started in 1962 were completed at St Coombs, Hantane, Kottawa and Passara, the design used being similar to that described in the Annual Report for 1960 (Visser & Kehl). On the results of these tests the following clones were selected and planted in the 1964 clonal proving trials at St Coombs and the three TRI sub-stations, along with the biclonal seedling progeny of TRI 2023 and 2026 from Lansdowne and a local seedling selection from Illuktenne.

1	TRI 1114	8	MO 208 (Mooloya)
2	TRI 1530	9	MO 241 (Mooloya)
3	TRI 1526	10	CAR 7/10 (Carolina)
4	TRI 2142	11	DW 12 (Downside)
5	MO 114 (Mooloya)	12	PLLG 2 (Poonagala)
6	MO 116 „	13	QT 4/4 (Queenstown)
7	MO 146 „	14	TRI 2024

2.2 Rooting ability of different types of cuttings

A trial was set down at St Coombs to test the rooting ability of cuttings taken from the main, lateral, and lower side shoots of mother bushes of clones TRI 2024, 2025 and 777, the design being randomized split plot with three replicates. The lower side shoots of some clones, particularly TRI 777 have a tendency to produce flowers.

The dry weights of roots and tops were recorded 8 months after planting of the cuttings. There was a significant difference between the dry weights of roots produced by cuttings taken from the main terminal shoots and those from lateral shoots as shown in Table 1, but not in the dry weights of the tops.

TABLE 1—*Dry weights of roots (g)*

	Treatments		
	Main shoot	Lower side shoot	Lateral shoot
Mean weights	5.81	4.94	4.24

Significant Difference 1.07 (P=0.05)

Both the dry weights of roots and tops were significantly higher for TRI 2025. The interaction between clones and types of cutting treatments was not significant.

2.3 Suitability of different rooting media

The suitability of five different rooting media; jungle soil (pH 4.8), tea soil (pH 4.6), Guatemala soil (pH 4.7), sub-soil with well rotted tea fluff (pH 4.8) and sub-soil (pH 5.0) for three clones, Sirikandura 106 (poor rooter), TRI 25 (average rooter), and TRI 2024 (good rooter), was tested in a trial set down at St Coombs in May 1964, the design being randomized split plot with four replicates. Similar trials were set down later in the year at Hantane and Kottawa using *Patana* soil as well.

The tea soil was collected from a very old tea field at St Coombs after scraping off the organic matter on the surface, while the Guatemala soil was from a field which had been under Guatemala grass for over one year. The results of three assessments carried out at the end of 8, 12 and 16 weeks after planting of the cuttings are given in Table 2.

TABLE 2—*Percentage of rooting*

(Date of planting cuttings—30th May 1964)

Clone	Date of assessment	Guatemala soil	Jungle soil	Tea soil	Sub-soil & tea fluff	Sub-soil
S 106	25th July	0	2.5	0	2.5	0
	22nd August	30.0	42.5	0	10.0	2.5
	19th September	37.5	62.5	17.5	10.0	12.5
TRI 25	25th July	0	0	0	0	2.5
	22nd August	15.0	35.0	2.5	2.5	0
	19th September	57.5	50.0	20.0	2.5	22.5
TRI 2024	25th July	60.0	80.0	32.5	7.5	20.0
	22nd August	87.5	92.5	75.5	47.5	47.5
	19th September	92.5	97.5	80.0	90.0	72.5

The earliest to strike root was clone TRI 2024 which also gave the highest rooting percentage compared to the other two clones. The percentage of rooting was about the highest in jungle soil and lowest in sub-soil. The final assessments will be made at the end of 8 months when the dry weights of roots and top growth will be recorded, and the results analysed statistically. Meanwhile it is significant that the growth of the good-rooting clone TRI 2024 continues to be just as vigorous in the tea soil as in the jungle or Guatemala soil in spite of the alleged toxic effects of tea soils on VP cuttings. It is proposed to repeat the trial in collaboration with the Agricultural Chemist using different levels of phosphate as super and saphos mixed with the rooting medium.

2.4 Transplanting of rooted cuttings

A transplanting trial was set down on 24-12-62 at Hantane using two clones TRI 740 and DK 8 (Diyanilakelle), rooted in polythene bags, to study the effect of the following treatments at the end of about 15 months on 30-3-64 when the assessments were made.

1 Polythene bag intact when transplanting in field
2 Slitting bag longitudinally at four places and planting
3 Removal of basal disc from bag
4 Complete removal of bag.

The results are presented in Table 3.

TABLE 3—*Dry weight of roots, stems and leaves in g*

Treatments	(1)	(2)	(3)	(4)	LSD (P=0.05)
Weight of roots	18.3	90.0	248.3	370.8	71.9
Weight of stems	22.5	135.8	381.6	605.8	138.3
Weight of leaves	5.3	40.8	157.5	157.5	94.4

Complete removal of the polythene bags when transplanting gave the best results. The percentage survival was also the highest, being 94.5 for treatment (4), 83.4 for (3), 41.7 for (2) and 12.5 for (1). There was no significant difference between clones in regard to survival percentage and dry weights of roots, stems and leaves.

2.5 Effects of hormones on rooting of cuttings

In a trial set down at St Coombs to test the effect of NAA, IBA, IAA, IBA+NAA, at 5000 ppm, Seradix B (2) and Fermate 76% on the rooting of cuttings of clones TRI 2024, TRI 2142 and TRI 25 there was no statistically significant difference in the percentage strike between the control and the chemical hormone treatments.

2.6 The effect of mutilation of radicles of seedlings on the formation and subsequent growth of roots

The intention was to study the behaviour of the roots of seedlings subjected to two different mutilation treatments since preliminary observations had indicated that they stimulated the production of more roots, particularly secondary tap roots. They were being compared with the root system of clone TRI 2024.

The treatments consisted of

1 Control—undamaged radicles
2 Radicle removed completely
3 Root-tip removed
4 Clone TRI 2024

The experimental layout was a simple randomized block design, each treatment being replicated six times.

Quantitative estimations of dry weight of roots, stems and leaves, plant height and root length were made at 12 and 16 weeks. The statistically analysed results are briefly summarized as follows :

Dry weight of roots per plant

There was no significant difference in the average root weight per plant between treatments 1, 3 and 4, but they were all significantly superior to treatment 2 where the radicle was completely removed before planting.

Dry weight of stem and leaves per plant

There was no significant difference between the control and treatment 3, where only the root tip had been removed. The complete removal of the radicle had a depressing effect on the dry matter content of stem and leaves, but it did not differ significantly from that of the clone at 3 months.

Average height of plant

The complete removal of the radicle had a depressing influence on the average height attained by the plant, three months after the treatment. This difference continued even after 4 months. The removal of only the root tip did not affect plant height at 3 months.

Maximum root length per plant

At three months the untreated control seedlings had a single tap root which was significantly longer than the roots of plants under the other treatments, Figure 1. There was no significant difference in root lengths between treatments 2 and 3 but numerous roots were produced at the cut ends, some of which appeared to function as secondary tap roots.

3 Clonal Proving Trials

(St Coombs, Kottawa, Hantane, Passara) Clonal proving trials were set down at St Coombs and the three TRI sub-stations every year since 1961, to test the performance of selected TRI and estate clones under different soil and climatic conditions in the low country, mid country and up country. Over 75 clones and 3 seedling selections consisting of an Indian, local and biclonal (TRI 2023 × TRI 2026) selection have been included in the trials in all four stations.

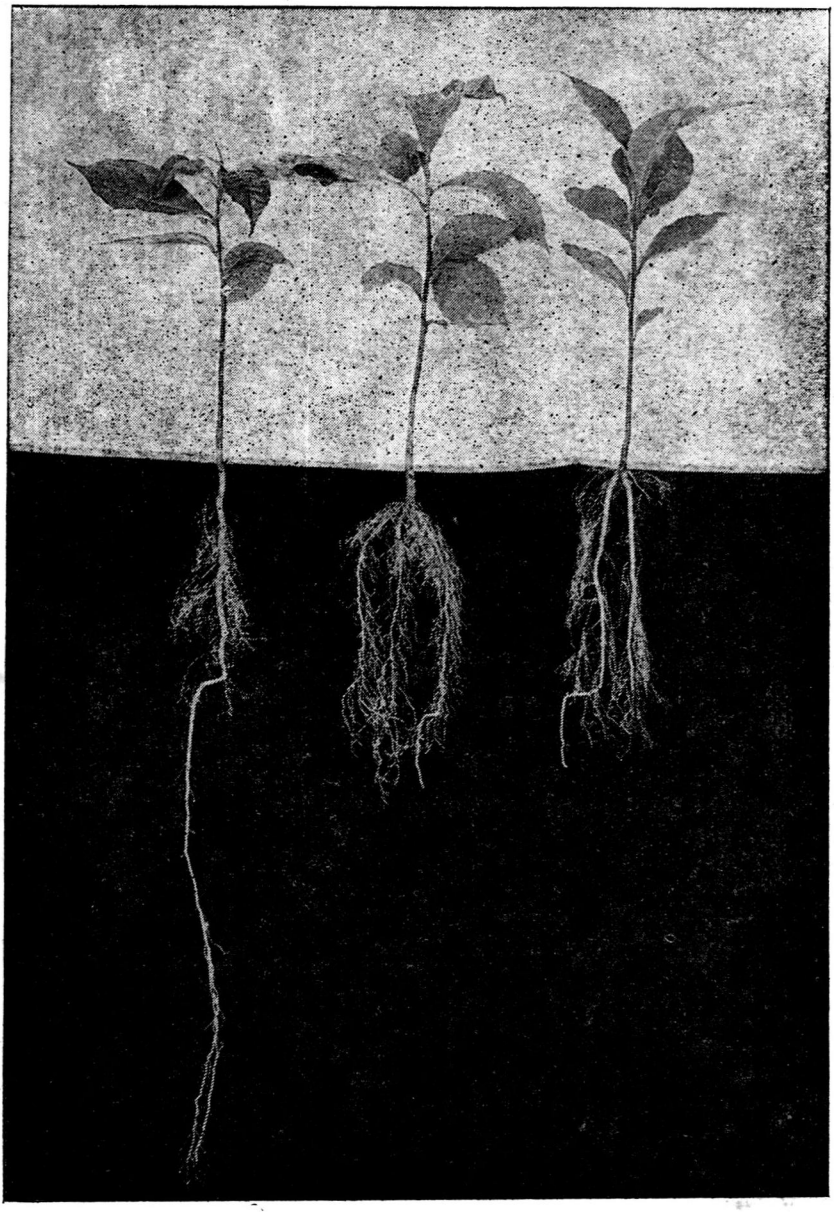

FIGURE 1—*Four month old tea seedlings showing (from left to right) root development when (a) radicle is left intact, (b) radicle tip is excised and (c) radicle is removed. Note appearance of secondary tap roots in (b) and (c).*

3.1 St Coombs (4,500 ft elevation)

The clonal proving trial set down in June 1961 includes 31 clones and one seedling progeny of a known seed bearer at Tocklai planted in four blocks, of which two are under dadap (*Erythrina lithosperma*) shade and two without shade. Each plot consists of 36 plants spaced 2′ × 4′, and is surrounded by a guard row of the red pigmented clone TRI 26. The dadap shade is planted at a spacing of 14′ × 14′.

One year's weekly plucking was completed in August 1964, and the highest yielders continue to be the popular TRI clones 2025, 2024, 2026 and 2023, with QT 1/5 (Queenstown), CR4 (Craig), CV4BI (Cannavarella) and PO26 (Poronuwa) as the lowest. The mean calculated yields in pounds per acre of made tea from each of the 31 clones and the seedling selection both under shade and no shade, for the year are given in Table 4.

TABLE 4—*Mean yields of Clones: St Coombs*

(Pounds per acre of made tea per year)

1	TRI 2025	—	2704	12	DT 1	—	2148	23	K 136	—	1506
2	TRI 2024	—	2454	13	CY 9	—	2147	24	T 5/38	—	1444
3	TRI 2026	—	2425	14	CV5/BI	—	1974	25	KEN 15/7		1302
4	TRI 2023	—	2338	15	T 5/3	—	1869	26	N 24/2	—	1253
5	GMT 9	—	2352	16	MT 18	—	1714	27	TRI 777	—	1190
6	TRI 2027	—	2298	17	SEED	—	1654	28	EN 31	—	1129
7	MT/BG	—	2280	18	UH 93	—	1645	29	PO26	—	1121
8	TRI 2151	—	2220	19	K150	—	1630	30	CV4BI	—	959
9	KEN 16/3	—	2212	20	NL 3/1	—	1621	31	CR4	—	941
10	TK 48	—	2193	21	DG 39	—	1602	32	QT 1/5	—	902
11	N	—	2190	22	PA 22	—	1550				

Significant Difference = 326 (P=0.05)

Key to abbreviation: Balangoda MT/BG, MT18, DG 39; Gonamotawa GMT9 ; Kenilworth KEN 16/3, KEN 15/7 ; Talankande TK 48 ; Diyagama N; Drayton 1; Tangakele CY9; Cannavarella CV4/BI, CV5/BI ; Thotalagala T5/3, T5/35; Uva Highlands UH 9/3; Kirkoswald K 150, K 136; Neluwa NL 3/1; Passara PA 22; Endane EN 31; Poronuwa PO 26; Craig CR4; Queenstown QT 1/5.

It will be noted that no less than 13 clones have given significantly higher yields and 8 clones lower yields than the seedling selection; the yield of the best clone being almost thrice that of the worst.

With only one replicate for the shade treatment, the yield differences between the clones under shade and no shade are not statistically significant although 26 out of the total number of 32 gave higher yields without shade, the average being 1894 lb of made tea per acre without shade and 1667 lb with shade.

The 1962 clonal proving trial which consists of 18 clones including the standard clone TRI 2024 was brought into weekly plucking from December 1964. They were planted in June 1962 and were not bent as those in the 1961 clonal trial.

The 1963 clonal proving trial consists of 12 clones including TRI 2024, and were planted in June 1963. The plants were not bent, but given a cut-across in July 1964 at about 12″ and again in December 1964 at about 14″.

The 1964 clonal proving trial consisting of 14 clones and 2 seedlings selections as mentioned under para 2.1 was set down in June 1964, and the plants bent in July 1964.

Judging from the growth of clone TRI 2024, which is included in all the trials as a standard clone for comparison, bending certainly helps to provide a more rapid coverage of the soil and to bring the bushes into plucking about 6 months or so earlier under the prevailing soil and climatic conditions at St Coombs.

3.2 Kottawa (100 ft elevation)

It is interesting to note from the results of one year's weekly plucking that in the 1961 clonal proving trial, the first two highest yielders are TRI 2023 and TRI 2026, which are already the most popular clones in the low country, and are followed by the Balangoda clones DG39, MT 18 and MT/BG, while the lowest yielders are KEN 15/7, TRI 777, CV4BI, CY9 and N. No less than 16 clones have given significantly higher yields than the seedling selections.

The yields of all the clones and seedling selection are shown in Table 5.

TABLE 5—*Mean yields of clones: Kottawa*

(Pounds per acre of made tea per year)

1	TRI 2023	—	3505	12	TRI 2025	—	2114	23	CV5/BI	—	1643
2	TRI 2026	—	3260	13	K 150	—	2020	24	NL 4/2	—	1642
3	DG 39	—	2678	14	GMT 9	—	1991	25	KEN 16/3	—	1625
4	MT 18	—	2650	15	QT 1/5	—	1933	26	SEED	—	1521
5	MT/BG	—	2527	16	NL 3/1	—	1855	27	T 5/2	—	1463
6	PO 26	—	2501	17	TRI 2027	—	1818	28	KEN 15/7	—	1365
7	T 5/35	—	2499	18	TK 48	—	1813	29	TRI 777	—	1325
8	TRI 2024	—	2379	19	TRI 2151	—	1787	30	CV4/BI	—	1242
9	UH 9/3	—	2279	20	K 136	—	1766	31	CY9	—	1195
10	DT 1	—	2188	21	EN 31	—	1752	32	N	—	900
11	PA 22	—	2179	22	CR 4	—	1655				

Significant Difference = 308 (P=0.05)

The difference in yield under shade and no shade treatments is also statistically significant, the average yields being 1804 lb and 2138 lb respectively of made tea per acre. The shade used here is *Gliricidia* at a spacing of 14′×14′.

3.3 Hantane (2500 ft elevation)

Yield records of 38 weekly plucks which were completed during the year in the 1961 clonal proving trial indicate with one exception the superiority of the more popular TRI clones over the estate clones, the first 5 clones in order of merit being DG 39, TRI 2025, TRI 2026, TRI 2023 and TRI 2027 and the last five being K 150, NL 4/2, CY9, TRI 777 and CV4BI. Here again the tendency is for the clones under no shade to give higher yields than those under shade, the average yields being 1148 lb and 935 lb respectively of made tea per acre.

3.4 Passara (3500 ft elevation)

The plucking of the 1961 clonal proving trial commenced on 16-4-64 and yield records of one year's plucking will be available next April. The TRI clones 2023, 2025, 2026 and 2027 continue to give the highest yields while the lowest yielders are CR 4 and QT 1/5.

4 Plant Breeding

4.1 Observations on hand-pollinated seedlings

In a batch of 83 seedlings planted out in 1963, 11 casualties were recorded. The observations on these seedlings could broadly be summarised as follows:

(*a*) There is noticeable variability among the progeny of the same cross.

(*b*) The progeny of the cross TRI 1114 × TRI 2024 are comparatively vigorous growers and consist mainly of the bigger leaved types.

(*c*) Wherever clone ASM 4/10 (Tocklai) was included in a cross, the progeny were generally pigmented.

(*d*) Clone DT 1 (Drayton) appears to be a poor combiner clone in that the progeny are slow growers and mostly of the small leaved types.

As the number of seedlings involved in each cross is comparatively small, it is not possible as yet to draw any definite conclusions as regard their performance in the field and the expression of parental characteristics. However, many of the characters are being studied independently and any outstanding bushes would be multiplied vegetatively and tested out as clones. In June this year a further batch of 125 seedlings involving the following combinations of crosses, of high yielding and high quality clones, namely TRI 2024 × TRI 777, TRI 2024 × TRI 1114, TRI 2024 × ASM 4/10 andTRI 2024 × DT 1 were planted out in fields Nos 8 and 9. Here again the pigmentation on either the stem or leaf, or on both is prominent in the progeny of the cross involving clone ASM 4/10.

The seedlings numbering about 130 under observation in the nursery consist of crosses between clones TRI 777, DT 95, TRI 2024 and ASM 4/10 The character that is easily observable is once again the pigmentation of the progeny of crosses involving ASM 4/10.

4.2 Studies on biclonal progeny (TRI 2023 & TRI 2026) obtained from two different sources compared to progeny of open-pollinated clonal seed (TRI 2024)

The biclonal material for this study was obtained from Lansdowne and Rambukkande estates in the Ratnapura district, and the open pollinated clonal seed from St Coombs. Briefly the treatments could be described as follows:

(*a*) Lansdowne biclonal seedlings TRI 2023 × TRI 2026
(*b*) Lansdowne biclonal seedlings TRI 2026 × TRI 2023
(*c*) Rambukkande biclonal seedlings of clone TRI 2023 & TRI 2026
(*d*) Open pollinated TRI 2024 seedlings

A description of the layout of the biclonal seed bearers is necessary to understand the apparent differences between the materials *a*, *b* and *c*. At Lansdowne the two clones are planted in alternate rows in equal proportions, so that the clonal bushes from which the seeds are collected represent the female parent, and the other clone the male parent. Whereas at Rambukkande the two clones are mixed in the proportion of 10 : 1 with clone TRI 2023 predominating.

Morphologically the seedlings belonging to groups *a*, *b* and *c* are similar in appearance in that the leaves are large, long, light green in colour and have an equal proportion of pigmented types to the non-pigmented ones. Growth measured in terms of height (Table 6) showed no significant difference between the mean heights of groups *a*, *b* and *c* but they were significantly taller than the open pollinated TRI 2024 seedlings.

TABLE 6

Growth of bi-clonal plants from different sources

	sources			
	d	*c*	*b*	*a*
Mean height of 100 plants in inches	14.06	16.89	17.79	17.98

Significant Difference at P=0.01 is 1.21

(*For key to sources see above*)

Irrespective of the nature of origin, the seedlings seem to behave alike as long as the same two clones are involved in the biclonal combination.

These seedlings along with their parental clones have been planted out in replicated plots in No 3 field to follow up their performance in the field.

4.3 A comparative study of seedling progeny obtained from eight commercial seed-gardens

Seeds obtained from 8 commercial seed gardens were germinated and planted out in the nursery to observe morphological differences, if any, between them, their growth characteristics and their suitability for field planting. The estates from which the seeds were obtained are Pettiagalla, Moolgama, Illuktenne, Glenanore, Kirimittia, Tembiligalla, Killarney and Chapelton.

The progeny from all the eight sources of seed appear to be of the Assam types although some are more vigorous than the others.

Vigour measured by the mean height of plants at eight months reveal that the progenies fall into 4 distinct groups, the seedlings of Killarney and Moolgama being very much superior to those of the other sources. The variation in the mean height of plants from the eight sources is represented in Table 7.

TABLE 7

The variation in heights of plants from different seed sources

Pettiagalla	Kirimettia	Chapelton	Illuktenne
7.12 inches	7.62 inches	8.55 inches	9.01 inches
Glenanore	**Tembiligalla**	**Moolgama**	**Killarney**
9.93 inches	10.24 inches	10.87 inches	11.09 inches

Significant Difference at P=0.05 is 0.51 inch

The performance of these seedlings in the field will be compared with that of a standard clone.

4.4 Field Selection: St Coombs field Nos 11 & 14

Early this year 63 bushes in the second year of their cycle were selected in the above mentioned fields, the basis for initial selection being the number of plucking points, vigour and spread of the bush. All bushes with adjacent vacancies or bordering roads and drains were not considered for selection. Plucking commenced in February 1964 and yield records of individual bushes were maintained over a period of 32 consecutive weeks. These bushes were pruned in October 1964, and it is intended to study all the possible characteristics associated with the bush such as morphological differences, rate of recovery from pruning, fermenting ability, leaf quality, yield, rate of rooting, relative susceptibility to Blister blight *etc* in order to develop an improved technique for the selection of the promising mother bushes.

Publications

RICHARDS, A. V. (1964) Some observations on drought resistance of tea clones. *Tea Quart.* **35:** 169-170.

RICHARDS, A. V. & SEBASTIAMPILLAI, A. R. (1964) A note on the identification of some TRI clones. *Tea Quart.* **35:** 168.

RICHARDS, A. V. (1964) Progress in planting of clonal tea in Ceylon. *Tea Quart.* **35:** 176-177.

REPORT OF THE CHIEF AGRONOMIST FOR 1964

H. N. Hasselo, Dr, Ir

General

Mr M. Sikurajapathy assumed duties as Technical Assistant. Otherwise, the staff remained the same.

Field experiments

1 NPK fertilizer trial

1.1 Growth and yield responses

The lack of response to N fertilizing of young tea plants (clone TRI 2024) and the growth depressing effect of large N dressings in the first 1½ years after planting have been reported in the previous Annual Report (Hasselo 1964).

Diameter measurements of the stem at ground level in the first half of 1964 and yields (expressed as lb made tea per acre per annum) obtained in the first 20 weekly plucks in the period August to December are shown in Figure 1.

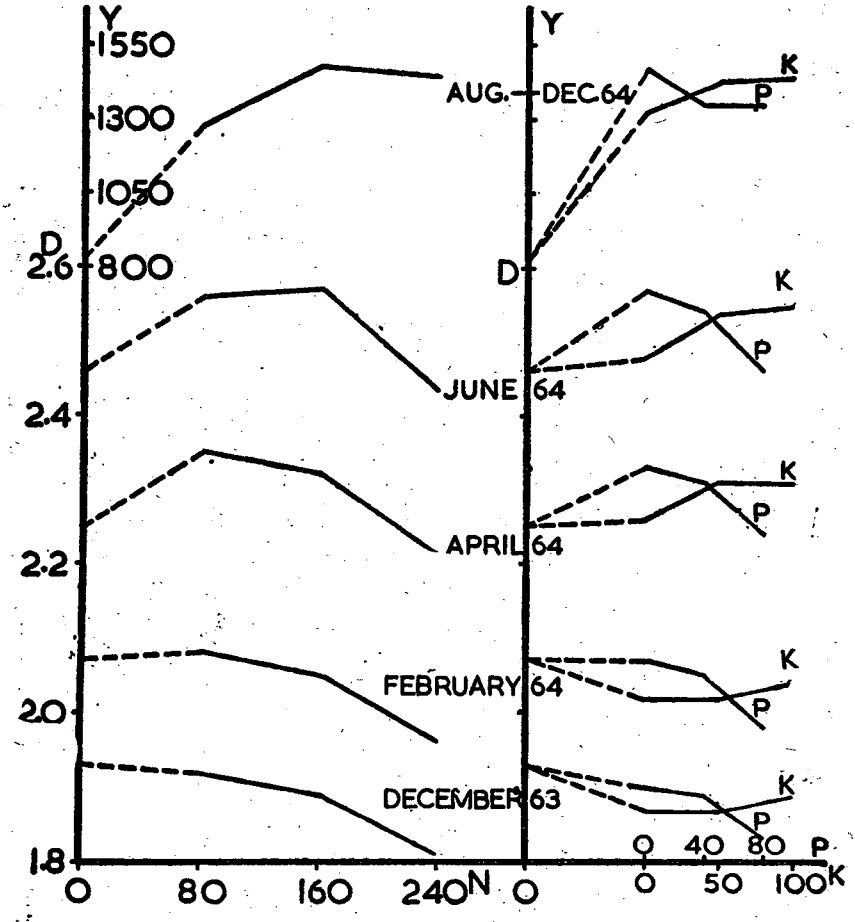

FIGURE 1—*Yield levels in period August—December 1964 (Y in lb made tea/acre/annum) and stem diameters (D in cm at the collar) in December 1963 in February, April and June 1964 at different levels of application of P_2O_5 (P), K_2O (K) and N (in lb/acre/annum).*

Growth responses to N-fertilizing became apparent for the first time early in 1964, first at low N-dressings (80 lb N) and later also at higher rates of application. As the difference between the no-fertilizer plots (O) and the P_o or K_o plots (which received no P or K respectively, though N and K, or N and P respectively) was of the same magnitude as that between the O and N80 plots, it might be concluded that both the growth depression observed in the first 1½ years after planting and the growth responses obtained in 1964 were caused by N rather than by P or K dressings.

It will be seen from Figure 1 that the yield increase (expressed as lb made tea/acre/annum) obtained in the first 20 plucks amounted to 455 lb tea (significant at $P<0.01$), or 55%, for the first 80 lb N applied and to 185 lb tea (significant at $P<0.05$) or 14% over N80, for the second application of 80 lb N. Amounts higher than 160 lb N had no effect or a depressing one. For the first 80 lb N applied 5.7 lb tea were obtained per lb N, the efficiency of N being considerably less for the second 80 lb N, *ie* only 2.3 lb tea/lb N. Beyond this level and up to 240 lb N there was even a loss of 0.37 lb tea per extra lb N applied. Though dressings of P might have depressed and those of K increased the yields, these effects nor those resulting from first order interactions between N, P and K reached significant levels. The interaction between N and K had the highest variance ratio, its level of significance being 10% approximately.

The mean yield level of the entire experimental area in the first 20 plucks was at the rate of 1,340 lb made tea/acre/annum. It varied, however, significantly ($P<0.001$) and by more than 100% between the six different blocks of the trial, *ie* from 830 to 1,780 lb tea in the lowest and highest producing block respectively. The three higher producing blocks are situated on gently to very gently sloping land. They produced 38% more crop in the period August—December 1964 than the three remaining blocks with shallower soils, two of which are situated on or near the crest of a hillock and one on the steep upper part of a slope. These findings confirmed others, *viz* that there are very large soil productivity gradients along sloping tea land (Hasselo 1964a,b) and that they are caused by soil erosion (Hasselo & Sikurajapathy 1965) of the steep upper slopes and soil accumulation on the less steep parts lower down the slope (Hasselo & Sandanam 1965).

Such productivity gradients may affect the efficiency of fertilizing as may be seen from Figure 2, where the differential effects of N on the three best blocks are compared with the three lowest producing ones of the trial.

It will be seen from Figure 2 that responses to N fertilizing (up to 80 lb N) on the three low producing blocks were already apparent in December 1963, but not until April 1964 on the better blocks. Though the N level of maximum response was, up to April 1964, higher on the less productive blocks, the adverse effect of larger N dressings (up to 240 lb N) was more marked on these than on the better blocks and persisted longer, *ie* until the end of the year. With increasing age of the plants the N level of maximum response increased, but more so on the more productive blocks. The trends suggest that the soils of the better blocks had a greater buffering capacity, thus alleviating adverse effects arising from deficient and excessive supplies of fertilizer and possibly soil N (see *1.2*).

Expressed differently, deviations from the optimum N supply will adversely affect the growth of young tea plants more on shallow than on deep soils. It will be shown later that the magnitude of these effects is not only dependent on the soil profile characteristics (depth of soil), but probably also on the soil organic matter content (see *1.1*), on the degree of tolerance of different clones to variations in the N supply (see *2*), on the Mg supply (see *3.2*), and on the amount of N applied per application.

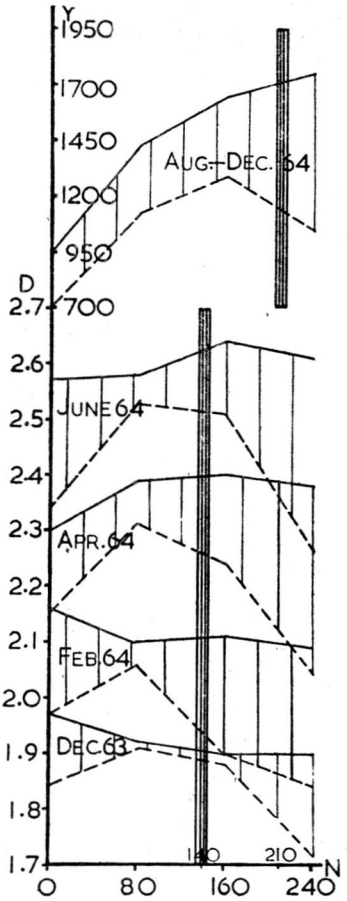

FIGURE 2—*Increasing response with time to increased N-applications. Differences in response between high producing (mean of Blocks I, III, & IV) and low producing (broken line) Blocks (mean of II, V & VI). Shaded columns represent N-amounts presently recommended for young tea plants of up to 2 and 3 years after planting respectively. For further explanation see Figure 1.*

In conclusion, the N supplying power of rehabilitated up country soils, was found to be large. On the basis of a response of 5.7 lb tea per lb N, it amounted to 56 lb N in the period August to December, 1964, *ie* some 2 to 2½ years after rehabilitation. On a yearly basis this would amount to some 145 lb fertilizer N per acre, ranging from 130 lb N for the low producing to 160 lb N for the three high producing blocks.

1.2 Fertilizer recommendations for young tea

These and following results bear out those reported in 1963 (Hasselo, 1964) and suggest that present fertilizer recommendations for young tea (Tolhurst 1961) are excessive (Figure 2), that the ratio between N on the one hand and P, K and Mg (see *3.2*) on the other is probably too low in the T 200 fertilizer mixture and that as a result growth of young tea plants is depressed. They also suggest that at yield rates of up to 1500 lb made tea per acre in the first year of production the same or a better growth performance could have been obtained with fertilizer dressings less than one third of the amounts presently recommended. These and other findings (see *2* and *3*) led to the following revised recommendations for young tea in the first 3½ years after planting (Table 1) and amount to a reduction of some 40% in present fertilizer rates.

TABLE 1—*Fertilizer recommendations for young tea*

Period after planting (years)	Types of fertilizer	Amount/ plant/ application (oz)	No. of applications/ annum	Method of application	Equivalent rate in lb N/acre/annum (Spacing 4′×2′)
0–½	Sterameal*	1	1**	around plant (1ft radius)	50 (105)***
½–1½	T 200	½	6	band along row or around plant at 1 ft from plant	50 (105–140)
1½–2½	T 200	½ or ¾	6 4	—do— but more than 1 ft from plant or broadcast	105 (140–210) 105 (140–210)
2½–3½	T 200	1–1½****	4	broadcast	135–170 (210)

*or similar organic manure, which releases N gradually.

**per half year.

***in brackets amount of N presently recommended (see Tolhurst, 1961).

****1½ oz if yields of 1,500 lb made tea per acre or more are expected.

The fertilizer amounts shown in Table 1 may still be too generous, particularly in respect of P, K and Mg (Ratio N : P_2O_5 : K_2O : MgO in T 200 is 10.3 : 7 : 7½ : 3) and on land which has been rehabilitated for more than 1 year. However, the chances that excessive fertilizer amounts might still adversely affect growth will be reduced because (*a*) only Sterameal as the source of nitrogen is suggested in the first six months after planting and (*b*) more emphasis is laid on broadcasting of fertilizers or, if placed, on applying the fertilizer farther away from the plants.

2 Confounded fertilizer, shade, spacing and clonal trial

The experimental area was planted in June/July 1964. The land was rehabilitated with Guatemala grass during 2 years and then left fallow for over one year except for a period of three months during which one crop of marigolds was grown. No fertilizers were applied after the Guatemala grass had been uprooted.

The trial consists of 6 blocks of 10 plots each. There are three levels of application of the T 200 fertilizer mixture (ratio N : P_2O_5 : K_2O : MgO = 10.3 : 7 : 7½ : 3), *ie* F_0 or no fertilizer, F_1 or the equivalent of 52.5 lb N/acre/annum in the T 200 mixture and F_2 or the equivalent of 105 lb N in the T 200 fertilizer mixture. At a spacing of 4′×2′ level F_1 would amount to half the presently recommended amounts of T 200 applied per plant and F_2 to present rates of application. The three planting distances are 4′×14″ (Do), 4′×28″ (D1) and 4′×42″ (D2) or the equivalent of 9334, 4667 and 3111 plants per acre. Spacing between the rows is 4 ft. The clones compared are TRI 2024 (C_0), DT_1, (C_1) and 777 (C_2). In three of the six blocks shade trees (Dadap and *Sesbania*) were planted at 16′×12′ one year before the tea was planted.

Every two months fertilizers are applied in a ring of approx 6″ around each plant and diameter measurements taken at the collar of the stem. Results obtained after six months growth are shown in Table 2.

TABLE 2—*Mean diameter increase (mm) in period July/December 1964*

Fertilizer levels	Spacing in the row			Clones			Mean fertilizer levels
	14"	28"	42"	2024	DT1	777	
F_0	4.4	4.1	4.2	4.6	4.4	3.6	4.2
F_1	4.3	4.9	5.1	5.6	4.9	3.8	4.8
F_2	4.5	4.7	4.3	4.4	5.1	3.9	4.5
Mean	4.4	4.5	4.5	4.9	4.8	3.8	4.5

LSD for fertilizer, clonal and spacing means : 0.28 (P=0.05)
0.38 (P=0.01)
0.50 (P=0.001)

It can be computed from Table 2 that differences in growth increments between clones amounted to between 25% to 30%, clone 777 being the slowest grower. Fertilizing at level 1(F_1) was significantly better (13%) than no fertilizer (F_0). At the highest fertilizing rate (F_2) however, growth was significantly depressed to half the increase obtained at level F_1. Differences in spacing had no effect.

The interactions between fertilizing levels (F) and clones (C) and between F and spacing distances (D) were significant at the 5% level of significance, but not the interaction between C and D (Figure 3 and 4).

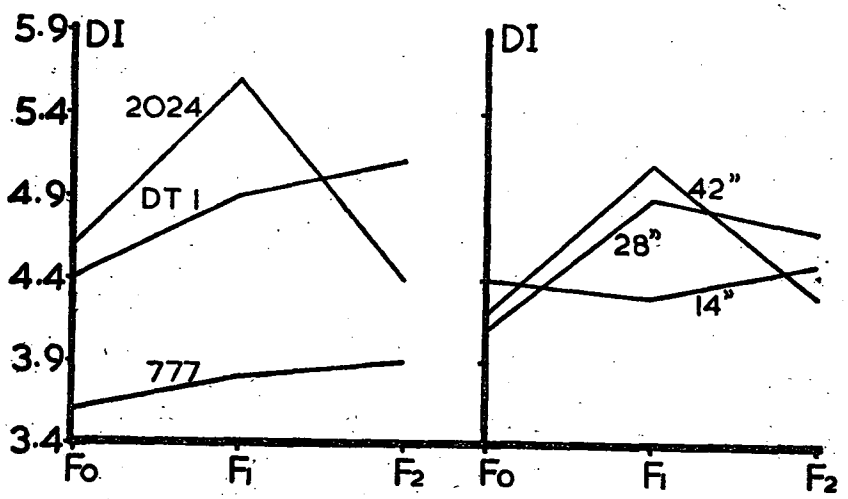

FIGURE 3—*(left) : Differential effect of increasing fertilizer rates (F) on growth of clones TRI 2024, DT 1 and 777 (DI is diameter increase in mm at the collar).*

FIGURE 4—*(right) : Differential effect of increasing fertilizer rates (F) on growth of tea (mean of clones TRI 2024, DT 1 and 777) planted 14, 28 or 42 inches apart in the row (DI diameter increase in mm).*

As compared with clones DT 1 and 777, clone TRI 2024 responded best to level F_1 but worst to excessive amounts of fertilizer (level F_2). Apparently DT1 and 777 were more tolerant though less responsive to high and low fertilizer rates respectively (see also pot and sand culture trials).

The difference in response between F_1 and F_2 increased also with increasing width of spacing (Figure 4). As the fertilizers were applied in a ring of about 6" around each plant, the fertilizer amount applied per plant was

naturally, higher, *ie* 1½ times, at 42″ than at 28″ spacing. Too high a concentration of nutrients owing to placement too near to the plant would explain why the adverse effect of F_2 was larger at 42″ than at 28″ spacing. However, the validity of this explanation could not be so easily tested against the results obtained at the narrowest spacing of 14″. For, although the fertilizer amount given to each individual plant at 14″ was only one half of that at 28″ and one third of that at 42″, the ring of fertilizer applied around any one plant at 14″ spacing overlapped those of its two neighbours in the row, thus increasing the concentration of nutrients actually applied within reach of the roots of any one plant.

These results were taken account of in the recommendations on placement and amounts of fertilizers shown in Table 1.

Also in this trial differences in growth rate between the six blocks, *ie* of up to 55% ($P < 0.001$), were much larger than those between the treatments.

3 Herbicide cum fertilizer trials

3.1 Short-term trials

Different assessments of the phytotoxic effects of herbicides to tea and weeds were made in several trials. The results are be published elsewhere (Hasselo and Sandanam, 1965).

3.2 Long-term trial

A long term herbicide cum fertilizer trial was planted with clone 2142 in July. The land was rehabilitated in the same way as described in **2.** The design is a 6 × 6 Latin Square with 3 levels of Simazine, *ie* no Simazine (hand weeded), 2 and 4 lb of Simazine per application per acre, and 2 levels of Dalapon confounded with the columns, half of them receiving 2 lb Dalapon per application per acre, the others none.

The fertilizer treatments consist of F000 (No fertilizer), F 100 (NPK at half the presently recommended (Tolhurst 1961) rate applied in the T 200 — fertilizer mixture), F 110 (*ie* F 100 plus Mg as Mg-sulphate at half the presently recommended rate applied in T 200 or the equivalent of half the presently recommended rate of application per plant of T 200), F 200 (*ie* twice the amount of NPK in F 100), F 220 (*ie* twice the amount of F 110 or the equivalent of presently recommended amounts of T 200) and F 221 (*ie* F 220 to which 100 lb aluminium sulphate per acre per annum is added). Each of these six treatments appears once in each column and in each row of the Latin Square.

There are 16 plants per plot which are surrounded by one guard row of clone 2043. The spacing is 4′ between and 2′ within the rows.

Diameters at the collar of each plant are measured and fertilizers are applied every two months. Simazine and Dalapon were applied for the first time in August, 6 weeks after planting. The second application was made in November just after the plants had been tipped to 13″.

Statistical analysis of the tipping weights and total weed weights collected in each plot 4½ and 6 months after planting respectively gave the following significant results.

Effect on Tea

(*a*) Fertilizing with NPK increased tipping weights significantly ($P < 0.01$) by 21%. There was, however, no significant difference between single and double dosages of NPK, *ie* between F 100 and F 200.

(*b*) Treatment with Simazine decreased tipping weights by 12% ($P < 0.01$). There was no significant difference between single and double dosages of Simazine, nor between the with and without Dalapon plots.

(*c*) Addition of Mg as magnesium sulphate to NPK at level 1, *ie* F 110 versus F 100, decreased tippings by 16% ($P < 0.05$).

(*d*) Differences in growth between the replicates (rows) were large (up to 30%) and significant ($P < 0.05$).

These results show that half the presently recommended rates of NPK — fertilizing would have sufficed (see also **1** and **2** above) even under the conditions of this trial, whose soil fertility must have deteriorated appreciably owing to serious soil erosion losses and the effects of exposure during the one year fallow period. The evidence supports the recommendations made under **1** (Table 1).

Simazine, though applied only once about three months before tipping, had a large adverse effect on tipping weight. As the plants were covered with plastic frames (diameter at ground level : 1 ft) during spraying operations, the adverse effect of simazine must have been due to uptake through the roots from the sprayed soil outside the screen, *ie* more than 6″ away from the plant. It furnishes indirect evidence for the recommendation (Table 1) to place fertilizers farther away from the plant than the six inches commonly adopted in estate practice.

The fact that symptoms typical for herbicidal phytotoxicity to tea were not apparent at the time of tipping, indicates that growth can be appreciably depressed, *ie* by more than 10%, without the appearance of chlorotic leaf symptoms. This is all the more serious because other studies (Hasselo and Sandanam 1965) showed that Simazine was among the least phytotoxic of ten herbicides tested.

After the second application of herbicides, made after tipping in November, phytotoxic symptoms were beginning to appear, though only 5 out of the 480 treated plants were affected by the end of the year. And even this might have been caused accidentally, *ie* by accumulation of herbicide treated soil eroded downwards and deposited around the chlorotic plants (Hasselo and Sandanam 1965).

The large reduction by 16% in growth caused by magnesium applied at half the presently recommended amount, supports the recommendations made in Table 1, namely not to apply Mg in the first 6 months after planting. It might be implied from this result that more frequent applications of Mg than once in a pruning cycle for mature tea, would be more beneficial, if at all.

Differences in tipping weights between the rows of plots amounted to 32%, much larger, therefore, than those caused by fertilizers or herbicides. It shows the large variations in soil productivity that can occur over short distances, the distance between the centres of two adjacent rows of plots being only 12 ft.

Effect on weeds

The total weights of weeds per plot collected in the first six months after the trial was begun were analysed statistically. In this period herbicides had been applied twice and fertilizers thrice.

(*a*) Simazine at level 1 (2 lb per application) reduced weed weight, as compared with that of the hand-weeded plots, significantly by 46% and at level 2 (4 lb per application) by 77%. Dalapon at 2 lb per application did not control weed growth significantly.

(*b*) As in the case of tipping weights of tea, differences in weed weights between the replicates were much larger than those caused by the treatments. They amounted to more than 300%. Fertilizer at level 1 increased weed growth by 19%, but reduced it by 5% at level 2. These differences were, however, not significant.

4 Rehabilitation trial

Plots to be rehabilitated with Guatemala grass for periods of 0, 1 and 2 years were laid out. Tea was uprooted and Guatemala grass planted in the plots to be rehabilitated for 2 years.

5 Spacing, clonal, fertilizer and bringing-into-bearing trial

This trial was planted in July, its design being a split plot with few plants per plot.

One disturbing factor in the interpretation of results from large scale field trials is the variation caused by large soil productivity gradients. One of the aims of this trial is to find out the amount of information that can be obtained from fragmented bits of land too small to accommodate a large field trial.

Pot and Sand culture trials

6 Pot trials

6.1 Three seven-month old nursery plants, one each of clones TRI 2024, 2142 and DT 1, were transplanted in July 1964 into each of the 96 concrete pots of the trial. The pots were filled with top-soil, containing 11% organic matter (determined by the method of Walkley-Black), or sub-soil, containing 2% organic matter, collected from the first 6″ and 2 ft deep respectively in field No 9, St Coombs Estate. The soils were put into the pots (67.5 lb top-soil and 76.0 lb sub-soil per pot respectively), treated with a nematicide, covered water-tight with plastic material during 3 weeks and then, after removal of the plastic covers, exposed to the weather for 3 months in April, May and June, before planting in July.

In half the total number of pots light intensity is reduced to approx 75% by artificial shading. Other treatments comprise 3 levels of NPK fertilizer, *ie* F_0 (no NPK), F_1 (half the presently recommended rates of NPK fertilizing for young tea) and F_2 (presently recommended amounts of NPK), either applied as the component fertilizers of the T 200 fertilizer mixture or as NPK compound fertilizer with the same ratio between N, P_2O_5 and K_2O as that of T 200). There are also two levels of Al, *ie* 0 and 100 lb aluminium sulphate per acre per annum. Fertilizers are applied and growth measurements are

taken bi-monthly. There are two replicates of each treatment. During dry weather the pots are watered. The quantity of water applied was insufficient to cause water to leak through the bottom of the pots.

Detailed growth results will be published in due course. Generally, growth trends appeared to be the same as those reported for the field trials. It is worth mentioning here that the growth response of clones TRI 2024 and DT 1 to increasing levels of NPK is similar to the interaction between these clones and fertilizer levels shown in Fig 3. The mean stem diameter of clone 2024 was, as compared with F_0, 19% and 17% larger for fertilizer levels F_1 and F_2 respectively after 6 months growth. For clone DT 1 these percentages were 20% and 29% indicating the greater tolerance of clone DT 1 to high nutrient concentrations caused by NPK dressings.

How deleterious presently recommended fertilizer amounts can be for young tea may be deduced from the occurrence of severe leaf scorch symptoms (Figure 8) caused by excessive fertilizing. It became apparent during the dry and sunny conditions at the end of the year. As scorch symptoms were observed in some of the F_0 plants (on average one out of three plants was affected) they must have been induced also by other causes, for instance by excessive amounts of soil N released as a result of the effect of alternate wetting and drying of the pot soils (see also *6.2* below).

The severity of these symptoms was assessed for each plant by totalling the points scored (1 for a slightly and 10 for a severely injured leaf) for each affected leaf on a plant (Table 3 ; Figure 5).

TABLE 3—*Total scorings of fertilizer scorch in different clones*

A Comparison of fertilizer effects in pots filled with topsoil or subsoil.

B Comparison of fertilizer effects in shaded and unshaded pots.

A

Clone	Top-soil				Sub-soil				
	F_0	F_1	F_2	Total	F_0	F_1	F_2	Total	Total clones
2024	24	184	273	481	14	241	288	543	1024
2142	4	50	73	127	13	59	103	175	302
DT 1	21	93	196	310	42	121	246	409	719
Total	49	327	542	918	69	421	637	1127	

B

Clone	Shaded				Unshaded			
	F_0	F_1	F_2	Total	F_0	F_1	F_2	Total
2024	18	250	299	567	20	175	262	457
2142	11	79	75	165	6	30	101	137
DT 1	28	118	222	368	35	96	220	351
Total	57	447	596	1100	61	301	583	945

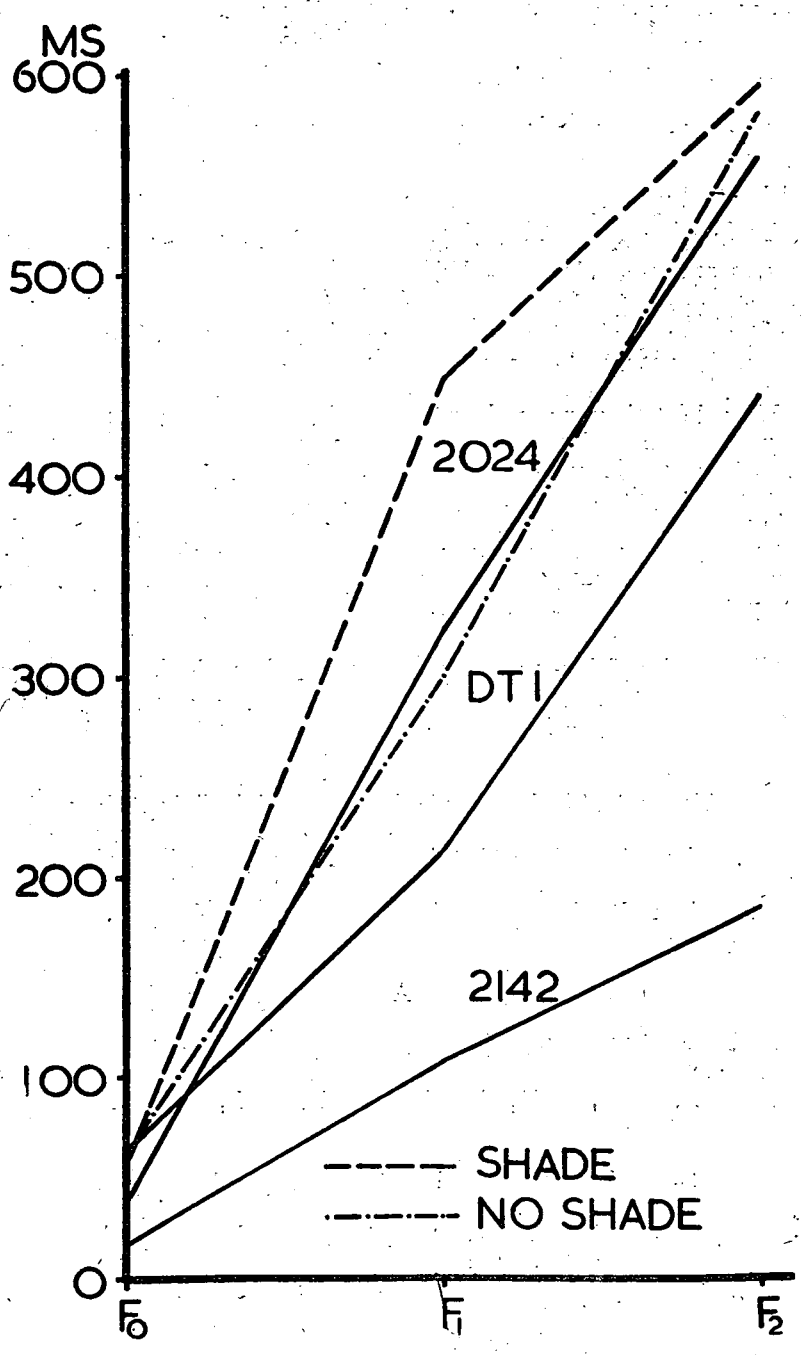

FIGURE 5—*Effect of increasing fertilizer rates (F) on fertilizer scorch (MS) scorings in leaves of clones TRI 2024, DT 1, and 2142 and of shaded and unshaded plants (totals of 3 clones).*

It will be seen from Table 3 and Figure 5 that with increasing fertilizer rates the severity of scorch increased ($P < 0.001$), particularly when the plants were grown in sub-soil (not significant) and under shade (sig. at $P < 0.07$). The greater adverse effect of sub-soil might be explained by the larger increase in soil nutrient concentration presumably because of the lower buffering capacity of the low-organic matter containing sub soil. The larger adverse effect of shade might have been associated with the lower nutrient requirements of

shaded plants and, therefore, their possibly greater susceptibility to high nutrient concentrations (there were no differences in growth rate between the shaded and unshaded plants since the time the trial was begun). The adverse effect of shade was largest, *ie* 50%, at level F_1 (Figure 5), *ie* the level at which—on average—the optimum growth response was obtained. It would support the claim that the optimum fertilizer level rises with increasing light intensity.

Evidence in support of the latter was furnished by the significant interaction ($P < 0.01$) between shade and fertilizer types, *ie* NPK applied as in the T 200 mixture or in the form of granulated compound fertilizer (Table 4).

TABLE 4—*Fertilizer scorch : Interaction between shade and fertilizer types*

	T 200	Compound fertilizer	Difference	Sig. Diff. P=0.05
Shade	451	649	−198	119.5
No shade	492	453	+39	
Difference	−41	+196		

It will be seen from Table 4 that, whereas scorch incidence was appreciably larger in the shaded plants treated with compound fertilizer as compared with T 200, it was the same or less in the unshaded plants. As compound fertilizer is entirely soluble in water and T 200 not, nutrient concentrations in the soil solution will increase more after compound fertilizer than after T 200 applications. Consequently, compound fertilizer would cause more scorch, particularly in the shaded plants, whose nutrient requirements are claimed to be less.

Clone 2142 scored (Figure 5) the lowest incidence of scorch, clones DT 1 and TRI 2024 having suffered more than twice and three times as much respectively ($P < 0.001$). These findings are in line with the trends shown for clones DT 1 and 2024 in Figure 3.

Marginal chlorosis (Figure 6 and 6A) was another leaf symptom which became apparent with the change from wet to dry and sunny weather. The colour of the leaf margin turns into yellowish white. The marginal discoloration is more marked in younger leaves and in clone DT 1 and may widen with time (Figure 6A). Its frequency of occurrence was scored in the same way as described above in respect of fertilizer scorch (Figure 7).

It will be seen from Figure 7 that this syndrome was mainly caused by light intensity. Though increasing fertilizer rates would seem to influence it also, clone DT 1 reacted by increased chlorosis, whereas clones 2024 and 2142 showed a reduction in its occurrence. These distinct symptoms may provide a useful index in future investigations on the susceptibility of clones to light intensity and possibly drought.

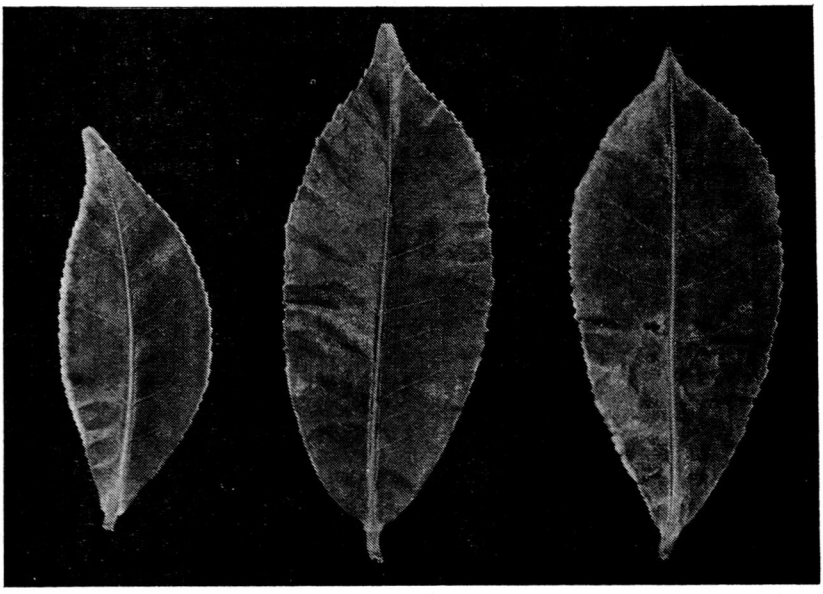

FIGURE 6—*Sun chlorosis in leaves of clone DT 1 (left), 2142 (middle) and 2024.*

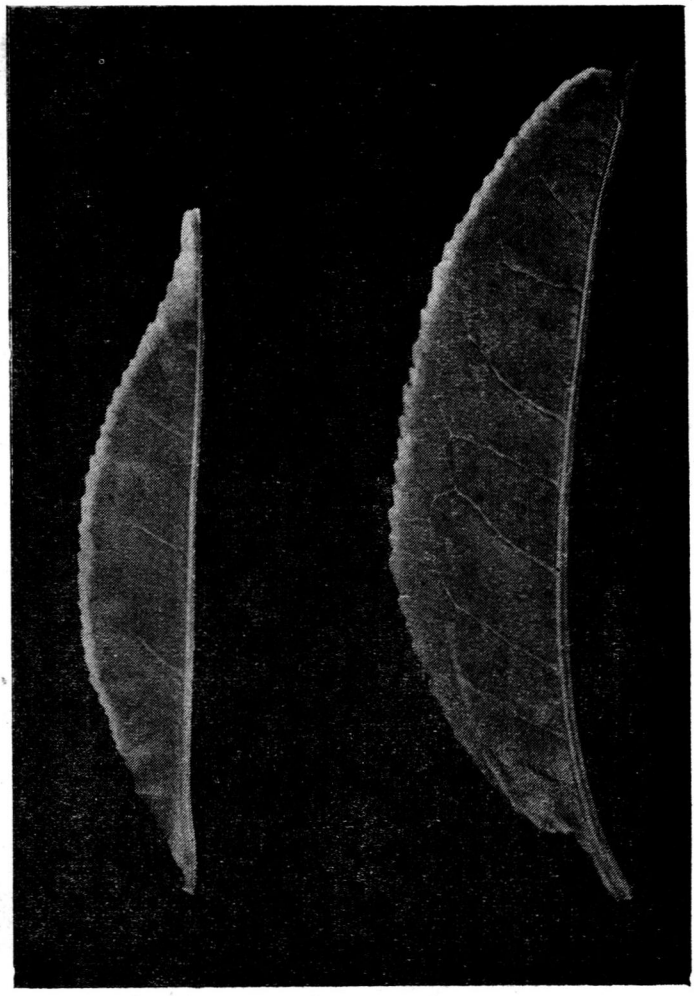

FIGURE 6A—*Sun chlorosis in leaves of clone DT 1. See also Figure 6*

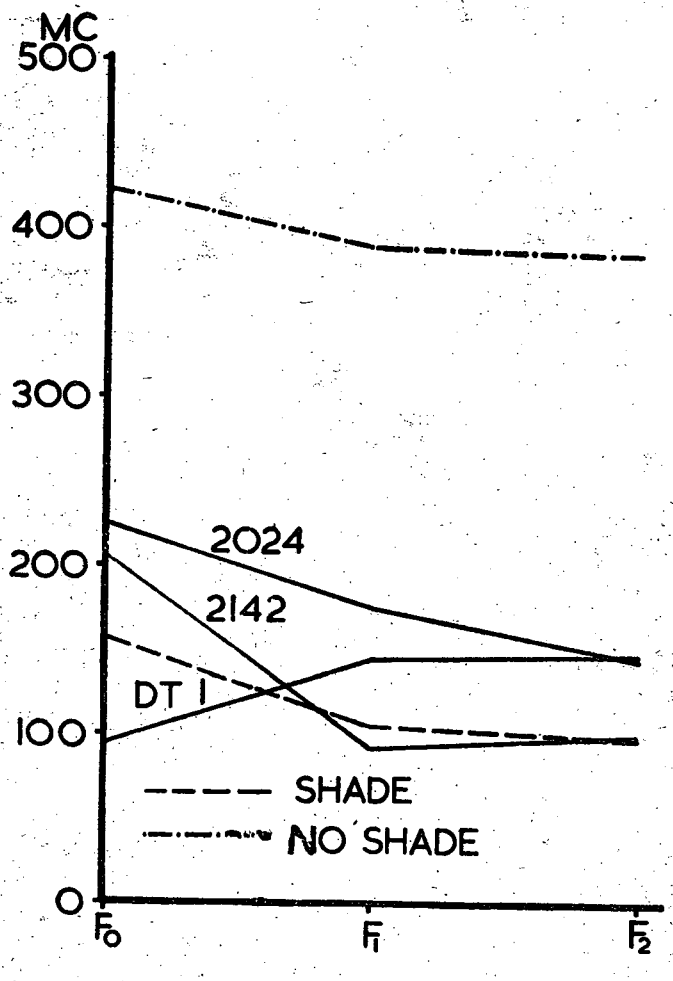

FIGURE 7—*Effect of increasing fertilizer rates (F) on marginal chlorosis (MC) scorings in leaves of clones TRI 2024, DT 1, and 2142 and of shaded and unshaded plants (totals of 3 clones)*

6.2 Samples of the top and sub-soils mentioned above (*6.1.*) were dried and stored during 10 months and, after re-wetting, planted with one year old cuttings from clone TRI 2024. The plants were kept in a greenhouse. One or two weeks after planting symptoms of "fertilizer scorch" appeared in the "top soil" but not in the "sub-soil" plants (Figures 8 and 8A).

Mineralization of soil carbon and the subsequent production of ammonia and nitrate — nitrogen have been found (Birch 1960 ; Hasselo 1961) to take place on moistening dried soils. The amounts of soil N released by nitrification depend on among others, the length of the dry period and the soil organic matter content. Birch (1960) found that a soil containing 11% organic matter could produce within a few weeks after moistening 250 lb N per acre 6" after a dry period of 3 months.

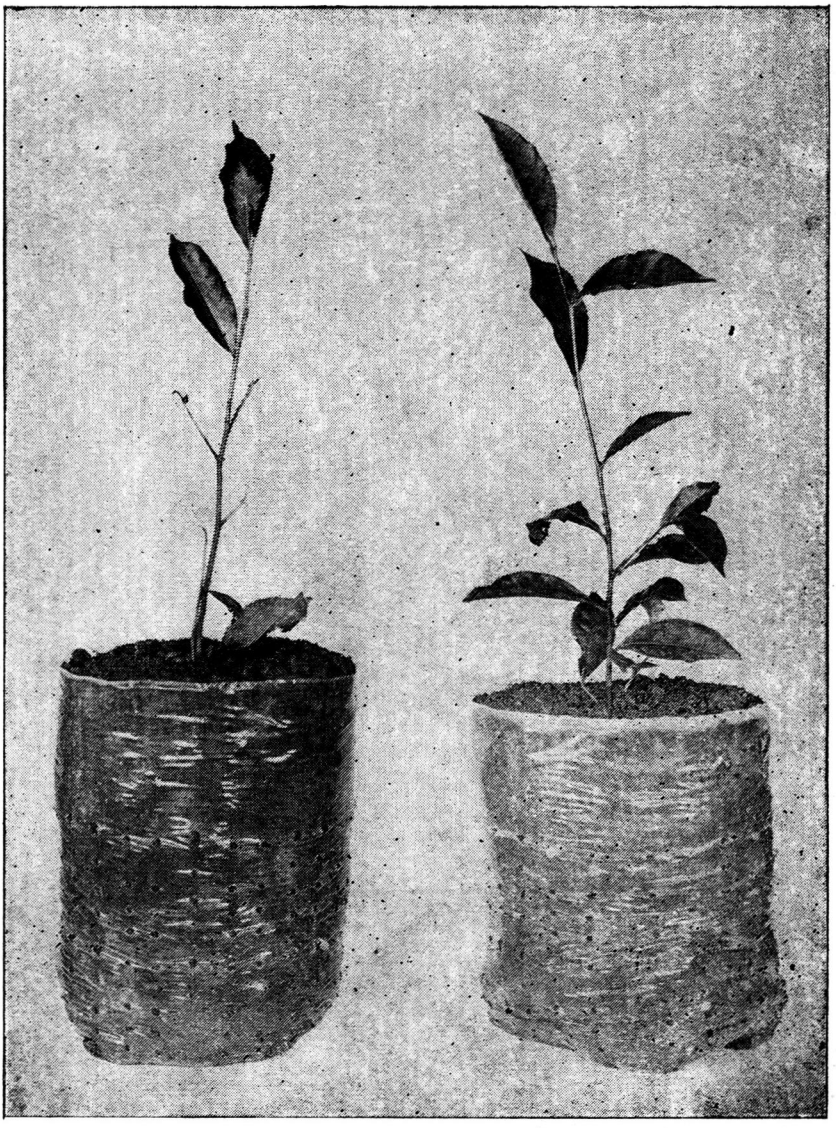

FIGURE 8—*Fertilizer scorch.* Left *Leaf Scorch and defoliation of plant grown in dark top soil.* Right *Healthy plant grown in reddish coloured sub-soil*

The six trial plants grown in top-soil (Figure 8) suffered from severe defoliation, while five of them eventually died. Therefore and in view of the much milder symptoms of fertilizer scorch observed in the pot trial plants mentioned (*6.1.*), it might be assumed that the leaf scorch symptoms (Figure 8) were indeed caused by toxic amounts of soil N equivalent to applications of fertilizer N of considerably more than 100 lb N per acre or 500 lb of sulphate of ammonia.

FIGURE 8A—*Soil profile horizon (see pencil) in field No 8, St Coombs, after 2 years rehabilitation with Guatemala grass. Note: distinct transition at 9" from soil surface from dark organic top soil (Munsell color wet: 10 YR 2/2; dry: 7.5 YR 3/2) to reddish colored sub-soil (Munsell color wet: 5.0 YR 4/4; dry: 5.0 YR 5/6).*

It might also be deduced (Hasselo, 1961) that in wet and cold weather when conditions are less and more favourable for the nitrification and build-up of soil organic matter respectively, plant roots and soil fauna will compete more for the then smaller amounts of available N. It might result in a (temporary) shortage of N and the occurrence of deficiency symptoms in tea, alternatively a larger growth response to N fertilizing (Hasselo 1965).

Knowledge of seasonal trends in the availability of N and other nutrients (Hasselo 1961) might become an important consideration for the proper timing of fertilizer applications and their amounts (see also **9**), particularly in areas with a pronounced dry season, like Uva.

6.3 Sand culture trial

The results have been submitted for publication (Hasselo 1965a).

7 Fertilizing Tea in Ceylon

No further progress can be reported in respect of the results of a survey and the analysis of yield and fertilizer data of Tea Estates in Ceylon, mentioned in the previous Annual Report (Hasselo 1964).

8 Foliar Analysis

An article on the mineral composition of tea leaves of increasing age will be published shortly. The nutrients analysed are N, P, K, Ca, Mg, Na, Mn, Fe, Cu, B, Zn, Mo and Al (Hasselo, 1965).

9. Soil-crop relationships

Studies on different aspects of this problem have been published, (Hasselo, 1964 a and b ; Hasselo and Sikurajapathy, 1965 ; Hasselo and Sandanam, 1965).

The large differences in soil productivity in the field trial blocks confirm that soil is one of the largest single factors affecting yield levels in the field. Therefore and because soil losses due to erosion were found to be appreciable (Hasselo and Sikurajapathy 1965) on sloping tea land, measures to reduce these losses would warrant more detailed investigations.

Joachim (1964, Table 6) has shown that crop response to a given annual amount of fertilizer is dependent upon the frequency of application. For instance, 300 lb N applied over a period of 2 years but split into 7 applications of 43 lb N each was equally effective as 450 lb N applied over the same period but in 5 gifts only, *ie* of 90 lb N each.

Adjusting Joachim's yield figures for the average N-response obtained, *ie* 2.16 lb made tea per lb N, they can also be expressed as shown in Figure 9.

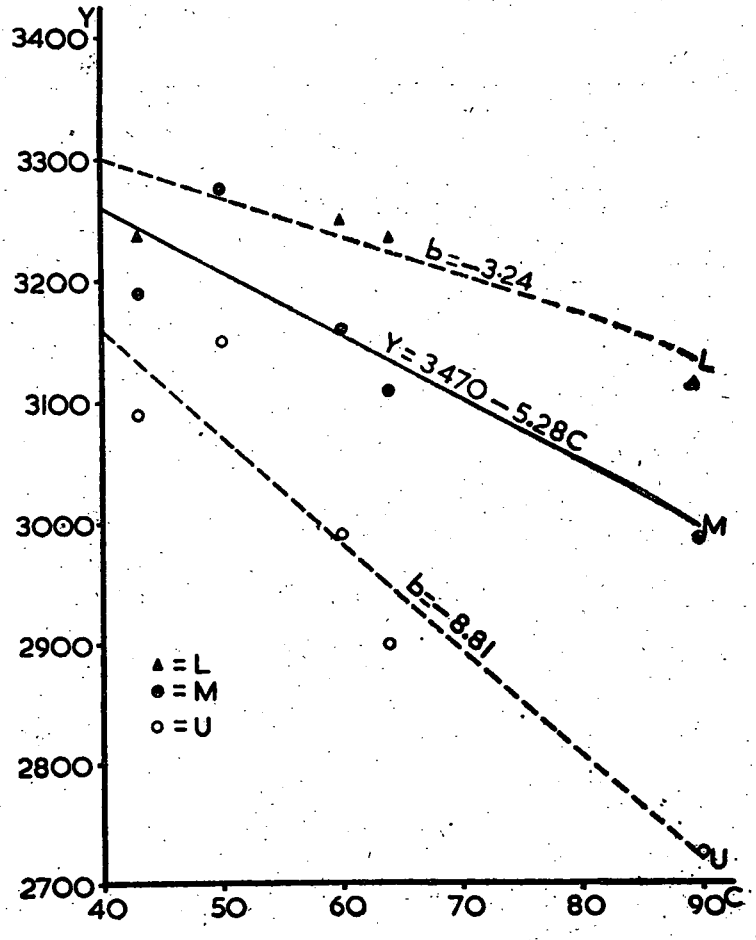

FIGURE 9—*The relation (M) between the magnitude of split fertilizer dressings (C in lb N/acre/application) to plots receiving fertilizer amounts of 150 or 225 lb N/acre/annum and yield (Y in lb made tea/acre/annum). L represents the relation on highly productive blocks in the middle and at the lower end and U on less productive ones at the upper end of the sloping trial area.*

It will be seen from Figure 9 that the larger the amount of N given per application at constant fertilizing, the lower the crop response, hence the N efficiency, will be. On the average, there was a loss of 5.28 lb made tea (regression coefficient for M in Figure 9 is –5.28 and significant at $P<0.02$) for any one lb N extra over and above 40 lb N per application per acre. At application rates of less than 40 lb N, the trend was not consistent.

It would appear also (see U and L-lines in Figure 9) that the depressing effect of application rates higher than 40 lb N was much larger on the upper slope soils (see Hasselo 1964 a & b), *viz* b= —8.8 lb made tea/lb N (significant at $P<0.05$), than on the lower slope soils, *ie* b= —3.2 (significant at $P<0.06$). It would be advantageous, therefore, to split the total annual amount of N to be given to an acre into dressings of not more than 40 lb N on upper slope soils and not more than, say, 50 lb N on lower slope soils. Thus, if a field receives 80 lb N per acre per annum in two applications of 40 lb N each, and this level is raised to 120 lb N per acre per annum, then this larger amount should be applied in 3 dressings of 40 lb N each rather than, for instance, in 2 applications of 60 lb N each.

In conclusion, these trends confirm not only the findings and recommendations reported here but also the results obtained in a sand culture trial (Hasselo, 1965a) and in detailed studies of yield and fertilizer trends on Tea Estates in Ceylon by Hasselo and Visser (unpublished results). They show that soil nutrient concentrations either above or below the optimum level can be equally deleterious to the growth of tea, though apparently more so on steep upper slope than on less steep lower slope soils.

Because current practice in use of fertilizers on Tea Estates in Ceylon is based upon yield levels, it fails to take account of the soil requirements (Hasselo, 1962). Therefore it is, at very least, neglectful of a constant source of income represented by the fertilizer that is wasted. Research to rectify lack of technical information on tea soils appears necessary. It would counter criticism such as recently expressed by Barker (1963) in similar circumstances. He wrote: "Current practice in use of fertilizers in the UK appears to be determined by unnecessarily large elements of guesswork, gamble and gullibility".

Acknowledgements

This being my last Annual Report before my departure I wish very gratefully to acknowledge the work done by and the keen and enthusiastic co-operation received from my Assistants Messrs W. B. Manipura, A. S. Sandanam, S. M. Kandasamy and M. Sikurajapathy.

Thanks are due to the Institute's Statistician for analysis of the results.

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REPORT OF THE LOW COUNTRY SCIENTIFIC OFFICER FOR 1964

L. H. Fernando, BSc, PhD

1 General

The Low Country Station, St Joachim, Ratnapura—The entire building programme of the Station consisting of the Factory, Laboratory and Bungalows for the staff was completed by the end of 1964. With the exception of officers for Technology, the full complement of research, advisory and estate staff is now in residence on the Station. Mr G. S. Muttettuwegama took over as Superintendent of St Joachim Estate from Mr C. Andrews at the end of December 1964. Dr S. C. Wanigaratne assumed duties as Research Officer, Agronomy, in May 1964, and Mr J. V. Sabanayagam as District Advisory Officer, Low Country, in December 1964.

Kottawa Sub-station—The Kottawa Sub-station in the Galle District continued to make steady progress with its extent increased to 50 acres, half of which has now been planted in experimental VP plots.

2 Advisory and Extension activities

The Low Country Scientific Officer attended meetings of the Low Country Station Committee, the Experimental and Estates Committee and the District Planters' Associations.

3 Research

3.1 Fertilizer Experiment on Seedling Tea at Endane—(In collaboration with the Agricultural Chemist)

TABLE 1—*Endane Fertilizer Experiment–Yield of Crop for the first year (November 1963 to October 1964) of the sixth cycle (1963 to 1965)*

Treatments lb/acre/yr		Crop lb made tea/acre/yr	% of Control
N	0	783	100
	40	783	100
	80	786	100
P_2O_5	0	786	100
	30	778	99
	60	788	100
K_2O	0	780	100
	40	801	103
	80	771	99
MgO	0	773	100
	20	794	103
	40	785	102
Dieldrex 6 pts/acre		834	107
Zinc sulphate 20 lb/acre		742	96
Control		776	100
Significant Difference at P=0.05		37	5

The 6th cycle of this experiment commenced on 1st November 1963. Nitrogen, phosphorus, potassium and magnesium continued to be tested, at three levels each, in a 3^4 factorial design in three blocks of 27 plots each, replicated twice. The three blocks in each replicate were used to compare the effects of Dieldrex and zinc vs none. As in the previous cycle there were no significant responses to nitrogen, phosphorus, potassium, magnesium and zinc in the first year of this cycle. The application of Dieldrex increased yields by 7%; the results are presented in Table 1.

3.2 Fertilizer Experiment on VP Tea at Palmgarden—(In collaboration with the Agricultural Chemist)

Nitrogen, potassium and magnesium each at three levels with three frequencies of application continued to be tested in a 3^4 factorial design. The second experimental cycle commenced in June 1963, and the results of the first 18 months of this cycle were analysed at the end of 1964, and are presented in Table 2.

TABLE 2—*Palmgarden Fertilizer Experiment (Clone 2023)–Yield of crop for the second cycle (June 1963 to May 1965)*

Treatments (lb/acre/year)		First six months (June to Nov 1963)		Second six months (Dec 63 to May 64)		Third six months (June to Nov 64)	
		lb/acre	% of control	lb/acre	% of control	lb/acre	% of control
Nitrogen (N)	75	618	100	1968	100	2161	100
	150	619	100	2174	110	2319	107
	225	610	99	2094	106	2431	112
Potash (K_2O)	50	617	100	2015	100	2264	100
	100	612	99	2078	103	2363	104
	150	618	100	2043	101	2285	101
Magnesia (MgO)	0	628	100	2045	100	2319	100
	24	610	97	2053	100	2288	98
	48	609	97	2038	100	2305	99
Frequency of application per cycle (times)	7	604	100	2015	100	2263	100
	9	621	103	2066	103	2297	101
	11	621	103	2066	103	2352	103
Significant Difference at P=0.05		29	5	119	6	151	7

It will be observed that in the first six months of this cycle none of the treatments had shown significant effects; in the second six months of the cycle there is a 10% increase in yield when nitrogen is increased from 75 lb to 150 lb/acre/annum; from 150 lb to 225 lb N per acre per annum there is no increase in yield, but yields at both 150 lb and 225 lb/acre/annum are significantly greater than the yield at 75 lb nitrogen per acre per annum. None of the other treat-

ments however were significant. In the third six months of this cycle the nitrogen effects were again significant with a 7% increase in yield when nitrogen was increased from 75 lb to 150 lb/acre/annum, and a further 5% increase in yield from 150 lb to 225 lb/acre/annum. The increase in yield per lb of nitrogen was 5.5 lb and 2.1 lb made tea respectively between 75 lb to 150 lb and 150 lb to 225 lb nitrogen/acre/annum. Moreover, examination of the interaction between nitrogen levels and frequencies of application indicate that the highest yield was obtained when 225 lb nitrogen/acre/ annum was distributed in 11 applications per cycle as illustrated below in Table 3.

TABLE 3—*Palmgarden Fertilizer Experiment* (*Clone 2023*)

Treatment combination of Nitrogen (N) and Frequency of application per cycle (F)	Yield of made tea in lb/acre for the third six months of the cycle	Percentage yields
N_{75} F_7	2167	100
N_{75} F_9	2167	100
N_{75} F_{11}	2169	100
$N_{150}F_7$	2300	106
$N_{150}F_{11}$	2347	108
$N_{225}F_7$	2343	108
$N_{225}F_9$	2412	111
$N_{225}F_{11}$	2560	118
Significant Difference at P=0.05	216	10

3.3 Zinc deficiency experiment on Seedling Tea at St Joachim—(*In collaboration with the Agricultural Chemistry Division*)

Zinc and nitrogen each at three levels and at three frequencies of application were tested in a 3^8 factorial design unreplicated. The results obtained at the end of 18 months of the first experimental cycle are presented in Table 4.

TABLE 4—*Zinc Deficiency Experiment*

Yield of Made Tea—First Cycle (*May 1963 to April 1965*)

Treatments (lb/acre/cycle)		Yield for 18 months lb/acre	% Yield
Nitrogen (N)	0	1952	100
	1	2077	106
	2	2166	111
Zinc Sulphate (Z)	0	1961	100
	1	2150	110
	2	2084	106
Frequency of application per cycle (times)	7	1999	100
	9	2016	101
	11	2180	109
Significant Difference at P= 0.05		159	8

On the yields obtained over the 18 months, zinc at 10 lb/acre/annum increased yield significantly by 10%. There was no further improvement in yield at the 20 lb/acre/annum level of zinc sulphate. Nitrogen when increased from 50 lb to 200 lb/acre/annum gave a significant increase in yield of 11%. The highest frequency of application, *ie* 11 times per cycle was the best.

3.4 Shade Trial on VP tea at St Joachim

This experiment was conducted by the Plant Physiology Division and was terminated at the end of 1964.

3.5 Investigations on pruning systems in VP tea at St Joachim

Rim-lung, centre-lung and cut-across pruning were compared, with and without a preceding rest period of two months, during which no plucking was done. A randomized block design of six plots replicated 4 times accommodated the six treatment combinations. Yields obtained so far over the nine months period indicate that the plots that were rested gave a significantly lower yield than those without rest. Rim-lung pruned plots gave the highest yield, but this was not significantly greater than yields of centre-lung pruned plots.

TABLE 5—*Investigations on pruning systems at St Joachim*

Yield in lb made tea per acre for 9 months from 1st June 1964 to 28th February 1965

	Rest	No Rest	Mean
Rim-lung	844	850	847
Centre-lung	741	855	798
Cut-across	712	817	764
Mean	766	841	
Significant Difference of Means (at P=0.05)		58	72

3.6 Effects and Interactions of Shade and Fertilizer on Seedling Tea at St Joachim

In this experiment nitrogen, phosphorus, potassium and magnesium each at three levels are compared in a 3^4 design in 81 plots arranged in 9 blocks of 9 plots each with an additional unfertilized plot in each block. The 9 blocks are used for comparison of three shade treatments, *ie* no shade, *Gliricidia* at 14′×14′ and at 7′×7′. The first experimental pruning cycle commenced in April 1964 and over the first year fertilizer effects will be investigated with uniform shade. The results obtained so far during the first six months of this cycle showed no striking effect with any of the nutrients tested.

3.7 The effects of Guatemala and various legumes on soil rehabilitation were investigated in two experiments. In the first, the effects of Guatemala, *Pueraria phaseoloides* and Guatemala grown with *Pueraria* on soil rehabilitation was the subject of investigation. The design was a randomized block replicated 4 times with the main plots sub-divided into 4 sub-plots to accommodate two levels each of nitrogen and phosphorus, *ie* 2 and 4 cwt of sulphate of ammonia and 1 and 2 cwt of saphos phosphate, per acre per year. All plots received muriate of potash and kieserite each at 1 cwt per acre per year.

The plots were planted with rehabilitation species in October 1963. The results obtained at the end of 1964 indicate that growth of Guatemala surpassed that of *Pueraria phaseoloides*. In the early stages *Pueraria* was very slow in establishment and growth, but later its performance was more promising, and Pueraria and Guatemala grew in satisfactory association. Observations between the levels of nitrogen and phosphorus tested indicated that lower levels were quite sufficient for satisfactory growth, and no differences either between levels of nitrogen or phosphorus were evident.

3.8 In the second experiment 15 species of legumes (listed below) were compared in a randomized block design replicated 3 times. The legumes were planted in December 1963 and received 1 cwt of sulphate of ammonia, 2 cwt of saphos phosphate, 1 cwt of muriate of potash and 1 cwt of kieserite per acre per year. *Calapogonium mucunoides*, *Crotalaria brownei* and *Crotalaria anagyroides* showed the best growth. At the end of one year, however, *Crotalaria brownei*, which is an annual, terminated its life cycle and attempts to re-establish it on the same plots failed. Satisfactory growth was also observed in plots of *Desmodium ovalifolium*, *Stylosanthes gracilis*, and among species of shrubs, *Tephrosia candida* appeared promising.

1 *Pueraria javanica*
2 *Pueraria triloba*
3 *Pueraria thunbergiana* (Kudzu)
4 *Pueraria phaseoloides*
5 *Crotalaria anagyroides*
6 *Crotalaria brownei*
7 *Flemingia congesta*
8 *Tephrosia candida*
9 *Centrosema pubescens*
10 *Calapogonium mucunoides*
11 *Alysicarpus vaginalis*
12 *Dolichos lab-lab*
13 *Indigofera teysmanii*
14 *Stylosanthes gracilis*
15 *Desmodium ovalifolium*

3.9 A comparison of VP Clones at St Joachim (In collaboration with the Adviser in Plant Propagation)

The 78 VP clones listed below were planted out in unreplicated observation plots in June 1964. Clone 2023 was included as a standard for comparison in each group of 10 plots. Seedlings of 2023, 2026 and bi-clonal seedlings of 2023 × 2026 were also included for comparison.

Kenilworth	—	KEN 15/7, KEN 16/3.
Gonamotava	—	GMT 9.
Diyagama West	—	N, DG, D.
Thotulagalle	—	T 5/35, T 5/3.
Passara	—	PA 22, MPA 1.
Somerset	—	E 7/27.
Balangoda	—	DG 39, MT/BG, MT 18, DG 7.
Neluwa	—	NL 4/2, NL 3/1.
Queenstown	—	QT 4/4, QT 1/5.
Poonagala	—	PUH 5, PCG 2.
Downside	—	DW 12, DW 29.
Moraya	—	MG.
Canaverella	—	MG 3/B1, NK 4/B29, CV 4/B1, CV 5/B1.
Talankande	—	TK 48.
Hellbodde	—	H 13/4.
Endane	—	EN 31.

Diyanilakele	—	DK 8, DK 1.
Drayton	—	DT 1.
Kirkoswald	—	K 136, K 150.
Tangakelle	—	CY 9, WY.
Uva Highlands	—	UH 9/3.
Craig	—	CR 4.
Craighead	—	CH 13.
Tillicoultry	—	TC 9.
Carolina	—	CAR 7/10.
Coombewood	—	CW 21.
Mooloya	—	M 209, M 21, M 20, M 241, M 208, M 116.
Wooton	—	W 3.
Poronuwa	—	PO 26.
Nayabedde	—	Nay 3.
Hulanduwa	—	H 1/58.
Tea Research Institute	—	777, 2022, 2046, 2024, 2023, 2045, 2027, 2026, 2043, 425, 2142, 2021, 2039, 1526, 2016, 1114, 331, 2025, 2020, 2151, CL26, 1530.
Karapincha (Palmgarden)	—	KP 204, KP 2039.
Lansdowne Seed	—	2023, 2026, Bi-clonal (2023 × 2026).
Rambukkande Seed	—	Bi-clonal (2023 × 2026).

3.10 Herbicidal effects on weeds in seedling tea at St Joachim

The efficacy of two levels of herbicides listed below were tested in plots of seedling tea.

1 Gramoxone	—	1 & 2 pints/acre
2 Diuron	—	2 & 4 lb/acre
3 Simazine	—	2 & 4 lb/acre
4 Aminotriazole	—	4 & 8 lb/acre
5 Dowpon	—	4 & 6 lb/acre
6 2.4. D	—	1 & 2 lb/acre
7 MCPA	—	1 & 2 pints/acre
8 2.4.5. T	—	1 & 2 pints/acre
9 Shell DH 34	—	2 & 6 pints/acre

22 plots in each block with 3 replicates accommodated the herbicide at each of the two levels along with two hand-weeded and two unweeded plots per block. The herbicides were applied to plots showing a moderate growth of weeds after the usual round of weeding in the previous month Assessments of weed growth were made in the herbicide-treated plots and the hand-weeded plots. The unweeded plots were used for comparison of weed growth and also for determining the effect of weeds on the crop. Gramoxone, diuron and simazine control weeds effectively. Other herbicides were effective to a lesser degree and the herbicide at the higher level showed toxic symptoms. Diuron and simazine at 2 lb per acre were sufficient to control weeds over a period of three months. Species of *Hedyotis*, *Alternanthera*, *Cyperus* and *Paspalum* were predominant, and they were effectively controlled by Gramoxone, diuron and simazine. Even the lower levels of these three herbicides resulted in toxic effects on the tea and *Gliricidia* shade trees, but these symptoms lasted for only about three months. Apart from scorching Gramoxone had no other direct or residual effect on the tea. Attempts are being made to investigate even lower levels of these herbicides. A statistical examination of yields will be made at the end of first and second years of the 2-year cycle.

3.11 An investigation of various methods of bringing VP tea into bearing at St Joachim

In August 1964, 81 experimental plots were planted and fertilized uniformly. Bringing-into-bearing treatments will be introduced in 1965.

3.12 A comparison of various VP clones at Kottawa Sub-station (In Collaboration with the Adviser in Plant Propagation)

Four experiments were planted in 1961, 1962, 1963 and 1964 respectively to compare various clones on this sub-station. In each experiment the design was a randomized block replicated 4 times, two replicates with shade and two without shade. The clones planted in each year are listed below.

1961	1962	1963	1964	1965
1 CV 5 B1	H 6 A1	DG	DW 12	2024
2 UH 9/3	CH 13	W 3	CW 21	DT 95
3 CR 4	2016	2021	H 1/58	K 145
4 777	2043	2046	QT 4/4	DK 8
5 MT/BG	2024	2045	PLIG 2	DK 17
6 KEN 16/3	D	ML 7	MO 146	DA 1408
7 PO 26	MG	DT 7	1530	QT 3/3
8 DG 39	MPA 1	DT 43	1526	TC 9
9 1024	H 13/4	W/2 145	1114	LD 999
10 CY 9	NK 4 B 29	DG 3	2024	C 34
11 EN 31	2022	TK 2	MO 208	PK 4
12 2025	N 3	3 275	MO 116	2045
13 2023	MG 3 B1	2024	MO 114	
14 T 5/35	2039	E 7/27	CAR 7/10	
15 K 136	2020		Seed (Illuketenne)	
16 DT 1	KP 204		Seed (Bi-clonal Lansdowne C)	
17 KEN 15/7				
18 T 5/3				
19 CV 4 B1				
20 2026				
21 MT 18				
22 2027				
23 N				
24 2151				
25 PAS 22				
26 Seed				
27 NL 4/2				
28 QT 1/5				
29 TK 48				
30 NL 3/1				
31 K 150				

2023 gave the highest yield, other promising clones were 2026, 2043, MT/BG, MT 18 and DG 39.

3.13 Spacing and Fertilizer Experiments at Kottawa

Two spacing experiments were planted at Kottawa in July 1961 and October 1962 respectively. In the first, each of the clones 2024, 2016 and QT 4/4 are spaced $4' \times 1\frac{1}{2}'$, $4' \times 2'$ and $4' \times 2\frac{1}{2}'$; in the second 2023, 2026 and 18B are spaced $4' \times 14''$, $4' \times 28''$ and $4' \times 42''$. Yields will be analysed at the end of the first cycle in each case; the indications are that the closest spacing gives the highest yield at this stage of development. All plots were initially fertilized uniformly; differential application at 100, 200, 300 lb, nitrogen per acre per year with an NPK fertilizer mixture was introduced as a factor in June 1964.

3.14 Effects and Interactions of N, P, K and Magnesium on VP tea at Kottawa (In collaboration with the Agricultural Chemist)

This experiment was planted in August 1963; bringing-into-bearing operations were done in 1964. Hoof and horn, urea formaldehyde and sulphate of ammonia are being compared as sources of nitrogenous fertilizer for young tea in this experiment.

REPORT OF THE PLANT PHYSIOLOGIST FOR 1964

U. Pethiyagoda, BSc, PhD, DIC

1 General

Mr S. Kandiah joined as Research Assistant and Mr S. Krishnapillai as Technical Assistant on 1st January. Mr S. Nagarajah returned in March from his studies abroad, having obtained the MS (California) degree.

Early in the year Mr H. W. B. Barlow, Head of the Plant Physiology Division, East Malling Research Station, spent a period of about four weeks in the Division under the special assignment of advising a scheme of research in Plant Physiology. His report embodied several important proposals which are being implemented. The Plant Physiologist continued to function as the Convener/Secretary of the Experimental and Estates Committee.

2 Artificial Shade Experiments

2.1 Shade experiment (St Coombs)

Weekly pluckings continued to be recorded in the new cycle.

In Table 1 are summarized the yields for the period after pruning.

TABLE 1—*St Coombs artificial shade trial. Yield of crop for the period April 1963 to December 1964. Each figure for yield represents the mean fresh weight in pounds per plot for the 86 plucks*

(*a*) Light intensity (as % sunlight)

	100	60	40
Mean yield	40.70	44.31	39.60

Differences between treatments are not significant.

(*b*) Fertilizer treatments

	N_1K_1	N_1K_2	N_2K_1	N_2K_2
Mean yield	38.91	38.65	44.94	43.64

LSD (at P=0.05) = 2.28

	N_1	N_2	K_1	K_2
Mean yield	38.78	44.29	41.93	41.18

LSD (at P=0.001) =2.90 not significant

Once again, while the higher level of nitrogen has increased yield, neither the levels of potash nor the levels of shade have affected crop. However, when the yields in the new cycle were arbitrarily divided into periods of sixteen plucks each, there was some indication that in the earlier stages, the unshaded plots were yielding better than either of the levels of shade. This is possibly related to the observed greater numbers of buds showing growth in the open plots. However, this early trend reverses with time and in the later stages, the lighter shaded plots yield best with the unshaded plots yielding least.

This trial has proved disappointing in the lack of clear-cut effects of the levels of shade on crop chiefly because of the unavoidability of the effects of protection from wind. There seems little likelihood that any clearer trends will emerge in the current cycle which is the first complete one since this trial commenced in May, 1961. It is therefore proposed to re-organise the experiment, particularly with respect to fertilizer levels, to a form which will enable a better appreciation of the effects of artificially reducing light intensity independently of shelter effects.

2.2 Shade experiment (St Joachim)

This trial continued to show neither shade nor fertilizer effects in the new cycle and has been discontinued. The yields in the new cycle are summarized in Table 2.

TABLE 2—*St Joachim artificial shade trial. Yield of crop for the period March 1963 to October 1964. Each figure for yield represents the mean fresh weight in pounds per plot for the 84 plucks*

(*a*) Light intensity (as % sunlight)

	100	70
Mean yield	68.87	69.80

The difference between treatments is not significant.

(*b*) Fertilizer treatments

	N_1K_1	N_1K_2	N_2K_1	N_2K_2
Mean yield	67.23	67.48	70.21	72.43

Differences between treatments are not significant.

	N_1	N_2		K_1	K_2
Mean yield	67.36	71.32		68.72	69.96
	not significant			not significant	

3 Mulch estimations under shaded and unshaded tea

This trial which has been described earlier, (Annual Report of the Plant Physiologist for 1961) continued during the year with leaf litter additions being assessed monthly. The recovering tea which had been pruned in June/July 1963 made no detectable contribution to the mulch until the early months of 1964.

At each monthly collection, a representative 100 g sample of litter from each shaded plot was separated into its components—*Grevillea*, dadap and tea and the calculated contribution of each species is presented in Table 3 below. The cumulative mulch additions are represented graphically in Figure 1.

TABLE 3—*Monthly collections of mulch under shaded and unshaded tea (St Coombs). The tea was pruned in June/July 1963. All figures are calculated as tons/acre dry matter*

	UNSHADED	SHADED				
		(a)	(b)	(c)	(a+b+c)	(b+c)
Month	Tea	Tea	Grevillea	Dadap	Total	Grevillea + Dadap
September 1963	—	—	0.0610	—	0.0610	0.0610
October 1963	—	—	0.0618	—	0.0618	0.0618
November 1963	—	—	0.0560	—	0.0560	0.0560
December 1963	—	0.0096	0.0829	0.0016	0.0941	0.0845
January 1964	—	—	0.1308	0.0048	0.1356	0.1356
February 1964	0.0354	0.0109	0.1007	0.0040	0.1156	0.1047
March 1964	0.0402	0.0228	0.0943	0.0068	0.1239	0.1011
April 1964	0.0475	0.0178	0.0817	0.0046	0.1041	0.0863
May 1964	0.0455	0.0231	0.0743	0.0021	0.0995	0.0764
June 1964	0.0588	0.0362	0.1548	—	0.1910	0.1548
July 1964	0.0945	0.0420	0.1056	0.0051	0.1527	0.1107
August 1964	0.1001	0.0552	0.1581	0.0091	0.2224	0.1672
September 1964	0.1208	0.0438	0.1177	0.0281	0.1896	0.1458
October 1964	0.1233	0.0465	0.0959	0.0426	0.1850	0.1385
November 1964	0.1382	0.1202	0.1166	0.0751	0.3119	0.1917
December 1964	0.1159	0.0774	0.0877	0.0018	0.1669	0.0895
TOTAL	0.9202	0.5055	1.5799	0.1857	2.2711	1.7656

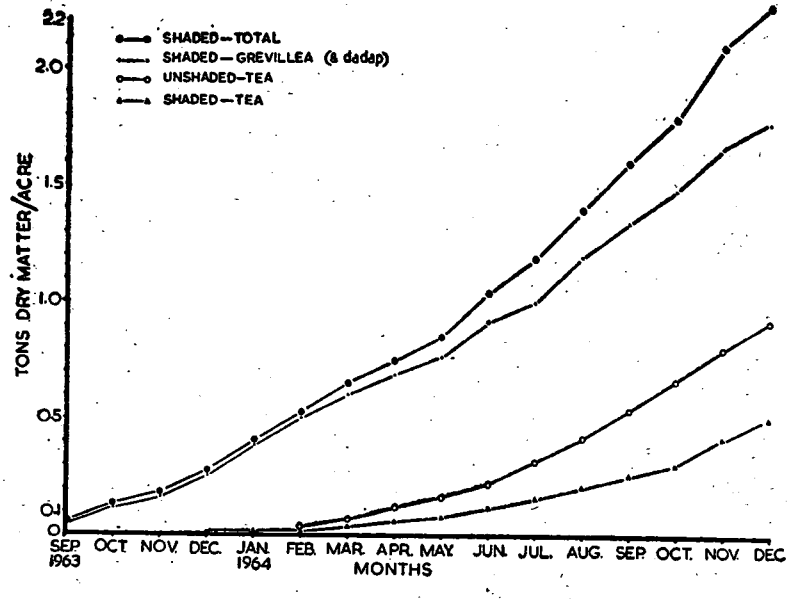

Figure 1—Cumulative monthly records of mulch additions under shaded and unshaded tea. The amounts of the separate components of the mulch are presented for the shaded tea

During the first nine months of recovery, until the canopy becomes fairly dense, the tea drops negligible amounts of leaf, after which there is a progressive increase. The shade trees at this stage contribute the major proportion of leaf droppings. It also appears that in the shaded plots there is a considerable reduction of the leaf shed by the tea as compared with the unshaded plots. It may be noted that at the time of pruning, the tea in shaded plots also carried more foliage (2.56 tons dry matter per acre against 2.04 for the unshaded plots).

4 The growth of Guatemala and Mana grasses at four locations

The amounts of loppings furnished by each of these two reconditioning grasses over about one year of growth were recorded in the Annual Report for 1963. After a further 6—9 months of growth, the grasses were cut at ground level and the land prepared for planting with tea.

After the removal of the grasses above ground, a sample pit of one yard cube was excavated at the centre of a plot of each of the two grasses at all four locations. The roots were quantitatively recovered in successive soil layers extending to a depth of one yard. The total amounts of roots and their percentage distribution in the successive soil layers are presented in Table 4 below. Alongside are given the calculated tonnage of loppings obtained per acre. All figures are expressed as dry matter.

TABLE 4—*Mana and Guatemala as reconditioning grasses (4 locations). Root recoveries in successive layers of soil at the time of final lopping, and returns of above ground loppings. All figures expressed as dry matter*

Location	Grass	Total roots	Percentage roots in each soil layer 0–6″	6–12″	12–24″	24–36″	Loppings (tons/acre)
Kottawa	Mana	130.13g	75.80	11.38	10.70	2.20	17.17
	Guatemala	856.98g	82.60	10.50	5.50	1.40	13.98
Hantane	Mana	370.00g	52.70	31.10	12.10	4.10	12.12
	Guatemala	982.00g	78.20	14.30	5.10	2.40	9.07*
Passara	Mana	481.40g	78.80	11.50	6.60	3.10	10.61
	Guatemala	1557.60g	75.30	16.20	6.20	2.30	10.65
St Coombs	Mana	316.60g	50.30	23.00	19.90	6.80	13.50
	Guatemala	727.73g	50.20	28.30	16.40	5.10	18.07
		Mean	67.99	18.29	10.31	3.45	

*Excludes one lopping when the grass had been stolen a few days earlier.

The calculated mean recoveries of dry root materials for Mana is 1.54 and Guatemala 4.91 tons per acre.

Points of special interest are:

(*a*) The considerably greater contribution of root material by Guatemala at all locations

(*b*) The high proportions of roots that are present in the top one foot of soil, and

(*c*) The absence of a direct relationship between above and below ground growth of the two grasses.

"Organic carbon" was determined by the Walkley-Black method on samples drawn from the top six inches of soil from the grass plots, along with control samples from surrounding areas kept bare of vegetation during the course of this trial. The determinations failed to reveal any large or consistent differences between plots and control.

Young clonal tea has been planted out on these former grass plots and growth is to be periodically assessed.

5 Studies on shoot growth

5.1 Growth of tipping shoots

In view of the importance of factors controlling shoot growth in determining the tea crop, a number of investigations were carried out during the year. They were primarily directed towards determining the inter-relationships between the leaves, internodes and axillary buds on "tipping shoots" and the manner in which the growth pattern of each regulates the others. (Mr S. Kandiah).

While a detailed account awaits publication elsewhere, the following summarizes the main indications so far.

(i) The terminal leaves on a shoot affect the extension of young internodes. The removal of the uppermost leaves that are still expanding results in a reduction of the final length reached by the internodes. The removal of the leaves that are somewhat more mature however, has the effect of increasing the length attained by the internodes.

(ii) The leaf just above a maturing internode is important in supporting secondary thickening of the conducting tissues. Its removal or isolation by removing a ring of bark tissue diminishes the development of such secondary tissues.

(iii) The removal of the upper leaves increases axillary bud development in leaves lower down. Similarly, removal of the lower leaves enhances axillary development above. For the continued growth of a developing axillary bud, its own subtending leaf is important.

(iv) Removal of the very mature leaves towards the base of a shoot results in multiple axillary growth if the terminal bud is also removed. A similar effect may be induced by ring barking of the internodes instead of bottom defoliation.

(v) Isolation of a shoot from the rest of the bush by ring-barking markedly reduces its extension. If in addition it is completely defoliated, death of the shoot results.

(vi) The removal of the four outermost unexpanded leaves in the bud markedly reduces internode extension. The application of a solution of gibberellic acid somewhat nullifies this effect. Similarly GA had a promoting effect on the areas of leaves to which it was directly applied. (This experiment was carried out by Mr Barlow during his visit to the division).

(vii) In general there is strong evidence that growth correlations exist between leaves, internodes and axillary buds. In an understanding of the relationships, the role of nutrients, growth promoters and inhibitors will need to be evaluated.

5.2 Banji in bushes in plucking

Very heavy shading (with coir matting) of bushes in plucking was observed to result in all of the flush shoots becoming banji in about three weeks. Subsequent removal of the shade soon restored active growth. Along with this resumption of growth, it was noted that profuse axillary branching had also resulted.

Since this might constitute a useful means of encouraging branching at the nursery stage, the experiment was repeated using bagged nursery plants which were nearly ready for planting out in the field. The results were disappointing but the work is to be repeated on plants of varying age.

6 "Growth analysis" trial

Little is as yet known of the effects of various cultural operations like "bending", plucking, pruning, tipping *etc* on the growth pattern of the tea plant. Experimental evidence on the influence of such operations particularly on root development and growth is also limited.

The technique of growth analysis where the effect of such operations on the total production of dry matter by the plant is studied is to be employed on a trial which was commenced during the year on No 2 Field at St Coombs.

Two clones, TRI 777 and TRI 2142 which are recognised as differing in their growth habits are used in this experiment. Observations will initially be carried out through two pruning cycles and the five treatments planned are summarized below.

	(First cycle)			(Second cycle)
(*a*)	Free growing throughout			
(*b*)	Bent — plucked	— pruned	— plucked	
(*c*)	Bent — not plucked	— pruned	— not plucked	
(*d*)	Bent — plucked	— pruned	— not plucked	
(*e*)	Bent — not plucked	— pruned	— plucked	

Each treatment is replicated five times, giving a total of fifty plots ($5 \times 5 \times 2$) for both clones.

Each plot has the dimensions 30×32 ft and with a spacing of 3×4 ft, carries a total of 99 experimental plants. It is proposed to sample two randomly selected plants from each of the relevant plots on each occasion. With the most generous provision of buffer plants around any sampling vacancy, a total of 20 plants could be used from each plot. This should allow 10 sampling occasions to be accommodated.

The effect of a given operation will be assessed against two standards—the untouched bush allowed free growth from planting and the bush which has received normal treatment up to but not including the operation in question.

The analysis of the sampled plants will constitute such determinations as total fresh and dry matter contents of each plant component (stem, leaf and root), total leaf area, depth and distribution of roots, stem and branch girths *etc*. While such assessment should not be too difficult in the early stages when the plants are small and expendable, later on destructive sampling will have to become less frequent and some internal growth correlations will need to be established between easily measurable parameters and total growth. It is intended to attempt to establish some such correlations involving leaf area, stem girth *etc*.

A simple non-destructive method for calculating leaf areas on the basis of length and breadth measurements has been worked out and will be reported upon elsewhere. (Mr N. S. Rajendram).

The trial was planted out in July 1964 and bending carried out in October. Two samplings have been carried out coinciding with the above operations.

7 Carbohydrate reserves in roots

Following on the evolution of satisfactory sampling and estimation methods (Annual Report of the Plant Physiologist for 1963), our studies in this field have been directed towards a re-assessment of the observed and implied roles of carbohydrate reserves in tea roots. (Mr S. Nagarajah).

Since sugars and starch comprise the recognised main sources of carbohydrate readily available for metabolic use, the method of estimation employed assesses these two fractions collectively as "total available carbohydrate" (Weinmann, 1947). As in previous work results are expressed as percentage "total available carbohydrates" (or TAC) based on the initial dry weight of the root sample.

(i) *Reserves and shoot growth:* Circumstantial evidence, based largely on the apparent increase of cases of unsatisfactory recovery from pruning in recent years and the special problems that appear to be associated with the pruning of high-yielding clonal tea, has led to a suspicion that low levels of root reserves may be a cause. To test the hypothesis that high yields may be accompanied by low reserve levels, analyses were carried out on root samples collected from some of the clonal test rows at Passara sub-station. Individual yield records for these rows were available and are presented alongside the figures for TAC.

TABLE 5—*Yield and carbohydrate reserves of selected clonal test rows (Passara). Yield is a calculated figure for pounds made tea/acre for the first cycle. Figures for carbohydrate reserves represent the mean of five root samples and are expressed as percentage TAC based on initial dry weight of sample*

Clone	Estimated 1st cycle yield	Root reserves % TAC
TRI 2023	10,318	18.77
TRI 2024	5,867	18.99
TRI 2025	5,822	14.45
MT/BG	4,994	17.48
NL 4/2	4,400	17.47
KEN 16/3	4,043	12.85
QT 4/4	3,740	16.85
T5/35	3,630	11.02
PLLG/2	3,322	16.30
TRI 740	3,207	20.50
DW 29	3,080	15.59
GMT-9	2,684	19.75
CV 4/B1	2,640	15.93
TK 48	2,222	18.09
TRI 2043	2,068	26.24
P 3	2,068	15.27
TRI 1294	2,046	12.06

The coefficient of correlation for yield and reserves is 0.0243 and falls far short of significance. Thus there appears to be little direct relationship between levels of root reserves and yield.

The study was extended to determine any relationship that may exist between the level of reserves at the time of pruning and subsequent recovery. A group of sixty old seedling bushes at St Coombs was selected and root samples from each of these bushes were analysed individually. When recovery was fairly advanced (58 days), counts were made of the numbers of developing buds on each of these pruned frames. At the time of tipping (142 days) all the newly produced shoots were stripped off each frame and the shoot growth on each bush was weighed individually. The results are presented in Table 6.

TABLE 6—*Reserves at time of pruning and subsequent recovery of sixty seedling bushes (St Coombs). Bud counts at 58 days from pruning and new growth stripped and weighed at 142 days*

% TAC	No of Buds	New Growth(lb)	% TAC	No of Buds	New Growth(lb)
33.44	203	2.94	21.73	30	1.19
33.33	74	1.13	21.31	125	3.56
30.59	101	3.00	21.09	19	0.50
29.11	28	2.00	20.78	59	1.19
28.90	118	0.56	20.71	20	0.63
28.69	151	2.75	20.50	123	3.00
28.48	72	0.88	20.08	114	3.75
28.16	93	2.50	19.99	170	2.44
28.06	56	1.88	19.85	43	1.00
28.06	78	1.44	17.80	47	1.13
27.42	196	2.63	17.05	60	0.94
27.42	168	4.50	16.79	125	1.69
26.83	141	2.56	16.77	47	0.75
26.58	116	1.38	16.67	64	0.63
26.37	114	1.06	16.62	86	1.63
25.53	64	0.88	16.03	38	1.00
24.68	237	3.81	15.40	91	2.00
24.68	194	2.25	15.40	21	0.88
24.64	51	1.50	13.92	244	2.50
23.71	45	0.69	13.84	28	0.50
23.63	171	2.50	13.82	111	1.69
23.12	55	2.50	13.08	104	2.44
23.10	106	1.13	13.08	232	1.38
22.92	55	1.00	13.08	67	1.00
22.89	66	0.63	11.14	32	0.88
22.78	166	3.50	10.38	51	1.19
22.78	25	1.13	10.04	68	0.50
22.78	14	1.94	8.95	14	0.31
22.53	66	2.19	8.86	153	3.25
22.10	30	4.44	8.61	26	1.50

These results again illustrate the absence of a direct relationship between reserve levels at pruning and subsequent recovery as estimated by bud counts and weight of new shoots produced. The partial correlation coefficients are as follows:

$$r_{sb.w} = 0.058$$

$$r_{sw.b} = 0.188$$

$$r_{bw.s} = 0.554^{***}$$

(Where s = reserves; b = bud counts and w = weight of stripped buds)

In order to test the possibility that differential recovery reflects varying capacities of bushes for the mobilisation of root reserves irrespective of their initial levels, root samples have been collected at the time the bushes were stripped of their new growth and await analysis.

Further, in an experiment of the Low Country Scientific Officer in progress at St Joachim, where resting has resulted in an increase of root reserves by an average of about 25%, there is no appreciable difference in recovery between the rested and unrested bushes as reflected by tipping weights (See Table 7).

TABLE 7—*St Joachim pruning trial. The effects of pre-pruning rest and types of pruning on carbohydrate reserves (as % TAC)*

	Treatment	At pruning time(A)	At tipping time(B)	(A–B)	Tipping wt (lb) (Total of 4 plots)
Rested					
	Rim Lung	7.30	3.07	4.23	40.19
	Centre Lung		1.83	5.47	23.00
	Cut across		1.38	5.92	23.38
Not Rested					
	Rim Lung	5.84	3.58	2.26	45.76
	Centre Lung		2.99	2.85	30.76
	Cut across		0.88	4.96	25.38

The results so far obtained would seem to suggest the absence of a direct relationship between shoot growth as measured by yield, tipping weight or degree of recovery from pruning and the levels of carbohydrate reserves in roots. It will be appreciated, however, that no account has hitherto been taken of the extent of the root system and hence the actual quantities of reserves available to or stored by the bush. This aspect will clearly bear scrutiny and will be examined in some future studies.

The foregoing evidence suggests that carbohydrate level alone may not regulate recovery from pruning. It is one of the factors limiting recovery and possibly if reserves are below a minimum threshold value, it can be of primary importance in retarding new growth. One other factor which is clearly of significance is the weather immediately following the time of pruning. That supplies of certain materials from the roots are important in supporting above-ground recovery from pruning, has been illustrated in an experiment where new shoot growth was seen to be markedly depressed by removing a complete ring of bark at ground level in bushes that had been clean pruned. Besides carbohydrates it is possible that roots may be the source of other substances, *eg* inorganic nutrients, elaborated nitrogenous compounds, growth factors and even water—which are necessary for supporting the growth of new buds. This subject is to be dealt with in greater detail in a publication now in preparation.

(ii) *Reserves and pruning*: It has been known for a long time that the level of carbohydrate reserves in roots shows a decline after pruning. This was shown to continue until about the time of tipping, after which the former levels were gradually re-established. The general pattern of such decline of reserves is under scrutiny at a range of elevations. The indications so far obtained are summarized below:

(*a*) There is a steep decline in the first few weeks immediately after pruning. This drop in reserves occurs before any recovery (bud-break) can be noticed on the branches. How these reserves moving out of the larger roots are utilized is not clear. This point is being examined.

(*b*) After the initial decline, there is a tendency towards a stabilization of the levels of reserves. The phase of decline extends over a greater period in the case of clean-pruned bushes than it does with lung-pruning. Consequently, the level of stabilization tends to be at a higher point in the case of the latter.

8 Pruning trials

8.1 Trials at St Coombs

Several small scale pruning trials were initiated at St Coombs in 1963 and were briefly outlined in the Annual Report for that year. These were designed mainly to yield information on the effects of resting and of different types of pruning on recovery, die-back and banji. Yield records were also maintained.

The main observations may be summarized as follows:

(i) A moderate (2–3 months) period of rest prior to pruning somewhat advances the start of recovery from pruning.

(ii) No benefits from resting are apparent on comparing tipping weights.

(iii) A prolonged (6 months) period of resting may actually reduce the numbers of growing buds.

(iv) Resting does not appear to result in increased crop in the new cycle, there being an indication that yield is actually somewhat reduced in the early stages.

(v) The retention of lungs speeds up initial recovery but exerts a depressing effect on growth if retained for too long.

(vi) Removal of all mature leaves below the plucking table does not reduce yield any more than a high cut-across.

(vii) Removal of half the foliage and branches—either longitudinally or in the form of a peripheral ring (side-pruning) does not markedly reduce crop, despite the period for which the pruned half is unproductive. The latter method proved beneficial to crop in one experiment (see also Visser, 1962).

(viii) No appreciable die-back was encountered in any of the experiments.

(ix) None of the treatments showed any marked influence on banji percentages.

8.2 Trials on estates

(*a*) *To determine the most suitable time for pruning:* An experiment was commenced on Tangakelle Estate (Dimbula) to determine the relative merits of pruning in different months of the year. Visual observations, coupled with records of tipping weight and intervals to bud-break and tipping are being made. The main observation will be the percentages of bushes showing differing degrees of recovery.

The results so far have shown that certain months (not necessarily those hitherto favoured) are superior to others for recovery. In all probability the ideal time for pruning will vary with different estates and districts and it would be advantageous to determine it experimentally in each case.

Steps are being taken to repeat the experiment in a different planting district (Nilambe) and to extend it to other localities where possible.

(*b*) *Dieback and deaths from pruning:* An experiment has commenced on one estate in the Pussellawa district with the possibility of another in the same area, to attempt to determine the causes leading to unsatisfactory recovery from pruning.

It is a pleasure to acknowledge the willing co-operation of the Superintendents and Assistants on estates where these trials are being conducted. The assistance of the Statistician in the analyses of experimental data is also gratefully acknowledged.

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REPORT OF THE ADVISER IN NEMATOLOGY FOR 1964

A. Kerr, BSc, PhD

General

The only staff change was the transfer of Mr A. R. M. Hassim from the Low-country Station to the Nematology Division.

During the year there were 78 estate visits ; 154 letters were received and 111 sent.

1 The meadow nematode—*Pratylenchus loosi*

1.1 Resistance and Tolerance of Tea Clones—The test started in 1963 was completed in 1964. Results are given in Table 1 and confirm (Kerr, 1964) that clones MO 146, MO 116 and DK 1 have appreciable resistance or tolerance.

A further test with 16 clones was initiated in April, but results are not yet available. Seedling progeny of clone TRI 2024 is also being tested for resistance.

A field trial with 6 clones, DT 1, MO 116, MO 208, MO 241, TRI 2025 and TRI 2142 was laid down on 4 estates, Chapelton, Derryclare, Mooloya and St Coombs. Plants are growing well on all estates. At planting, the number of nematodes in the soil was very low and had not increased on St Coombs after 6 months, although this might be because samples were taken from a root free zone between the rows. Nematode numbers will be measured every 6 months on all estates.

1.2 Rehabilitation Tests—An important reason for soil rehabilitation is to eliminate or reduce the number of soil inhabiting pathogens. A field experiment was designed to compare nematode numbers in soil,(*a*) under the normal rehabilitation crop, Guatemala grass and (*b*) under potatoes, followed by Guatemala grass. (Potato growing during the rehabilitation period has been recommended by the Government, but potatoes are relatively susceptible to *P. loosi* (Kerr, 1964)).

Nematode numbers were measured immediately after uprooting infected tea and then at monthly intervals. There were 4 replicates of each treatment and plots were randomized. Results are shown in Figure 1. Nematode numbers fell rapidly during the first few months of rehabilitation, and there was no significant difference between treatments.

During the rehabilitation period *P. loosi* may survive for at least 18 months and probably for longer on old tea roots left in the soil after uprooting. Experiments have been started to determine the survival of nematodes during the rehabilitation period following the removal of old infected tea by (*a*) winching and (*b*) chopping. Nematode numbers will also be measured after clonal tea is planted.

1.3 Marigold Field Trials—The marigold field trials on Logie and St Coombs estates have continued. In 1963 on St Coombs, marigold plots yielded significantly higher than control plots, but in 1964 there was no significant difference. On Logie there was no significant difference in 1963 or 1964. On both estates there is quite a good cover of tea and the marigold plants have been shaded out, leaving only a very thin stand of marigold. This may be the reason for the lack of significant differences in 1964, but in two further experiments on St Coombs, marigolds have had no effect on yield in the first year after pruning, although the stand of marigolds was quite dense.

TABLE 1—*Second Test of Clones for Resistance and Tolerance, using Beds of Infested and Fumigated Soil*

Criterion	Clone																		
	DT95	M146	M116	DK1	M208	M114	DK17	M209	GMT9	W3	TRI 2117	M241	CH33	TRI 2027	DK14	TRI 2024	TRI 2151	DR12	Sig. Diff. (P=0.05)
Shoot growth (infested soil)	152.8	134.9	121.1	108.1	69.7	66.5	56.9	55.1	49.2	48.4	47.5	47.2	44.9	33.4	24.4	21.4	14.6	12.4	shown by lines
Nematodes/g root (infested soil((Transformed data)	9.34	16.43	20.33	16.93	—	—	—	—	—	—	—	—	—	—	—	25.9	—	—	3.79
% reduction of yield (*cf* infested and fumigated soils)	27.5	58.3	54.0	51.4	44.5	43.5	48.1	33.3	91.6	71.3	68.8	72.3	76.6	89.6	87.7	95.3	94.6	95.7	24.0
No of surviving plants in infested soils (out of 16)	16	16	16	16	16	13	15	11	15	11	9	15	13	14	11	13	3	7	—

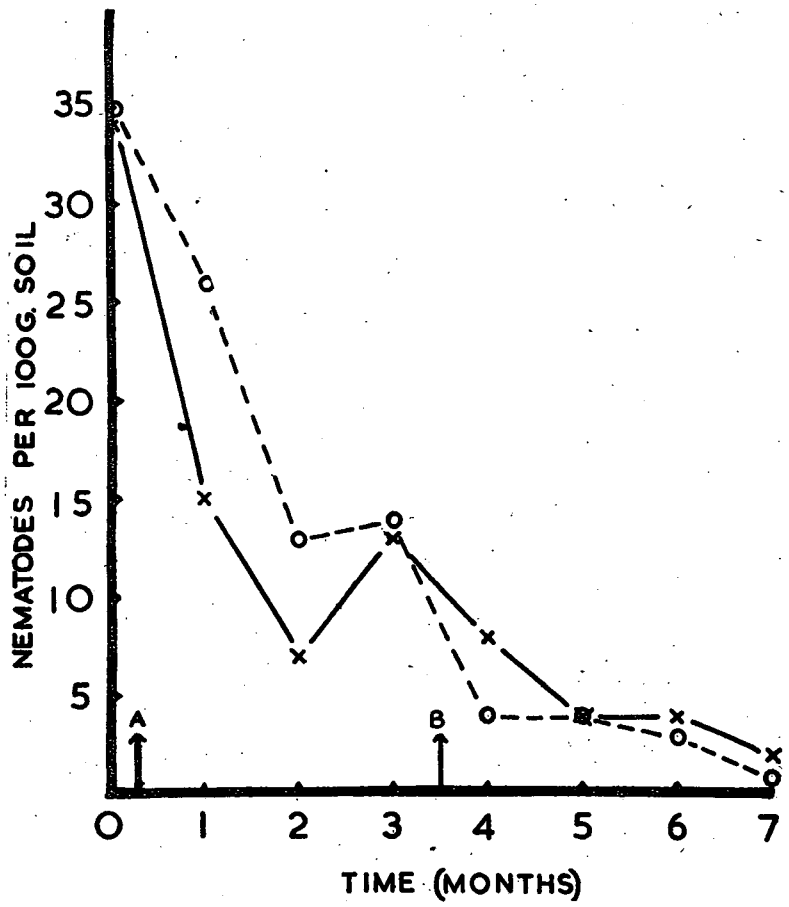

FIGURE 1—*Numbers of* P. loosi *in soil during the first seven months of the rehabilitation period*
X——————X Potatoes followed by Guatemala grass.
O- - - - - - - - - - - - - - - - -O Guatemala grass.
A=Potatoes and Guatemala grass planted.
B=Potatoes harvested and Guatemala grass planted.

Soil and root samples were taken from the original St Coombs trial where there was a significant difference in yield in 1963, but a difference in nematode numbers in marigold and control plots could not be demonstrated.

1.4 Differentiation of Populations of P. loosi—There is some evidence that nematodes from different localities vary in pathogenicity, (Hutchinson, 1963) and two experiments were designed to provide more information on this. In the first experiment, rooted cuttings of clones DK 1, DT95, MO 208 and TRI 2024 were planted in fumigated Guatemala grass soil in polythene bags and 6 months later were inoculated separately with nematodes from Adam's Peak and Chrystler's Farm estates. Nematode numbers in each bag were counted after 7 months, but results were too variable to be significant.

In the second experiment clone TRI 2024 was exposed to 5 nematode populations in naturally infested soils and also in inoculated Guatemala grass soil. One of the populations had to be eliminated from the experiment because of insufficient nematodes for the initial inoculation. After 12 months, shoot weight and nematode numbers were measured and results for the plants

growing in Guatemala grass soil are given in Table 2. Nematodes from Wooton Estate caused significantly more damage and those from Chapelton significantly less damage than did nematodes from the other two estates. Nematode numbers suggest that, under the conditions of the experiment, nematodes from Wooton Estate can multiply faster than those from other estates and this may be the reason for the greater pathogenicity, although difference in numbers was significant only in the fumigated soil. On the other hand the low pathogenicity of nematodes from Chapelton cannot be explained by a low multiplication rate as numbers were not significantly different from Derryclare and Campion. At the end of the experiment the sex ratios of nematodes from all samples were determined and are given in Table 3. There is strong evidence that *P. loosi* from different sources may differ significantly both in pathogenicity and in sex ratio.

TABLE 2—*Growth and level of infection of Clone 2024 inoculated with* P. loosi *from different sources*

SOIL TREATMENT	Source of nematodes used in inoculation Wootton	Derryclare	Campion	Chapelton	Control	Significant differences P=0.05	P=0.01	P=0.001
			SHOOT WEIGHT (g)					
Fumigated	42.8	159.3	176.7	274.9	251.4	44.3	NS	NS
Not Fumigated	51.3	111.9	116.4	253.6	294.8	44.3	NS	NS
			NEMATODES PER GRAM ROOT					
			(Transformed Data)					
Fumigated	33.55	16.41	14.38	18.32	—	6.24	8.36	11.00
Not Fumigated	22.29	20.27	19.81	17.52	—	NS	NS	NS

TABLE 3—*Sex ratio of nematodes from different sources*

	Source of Nematodes				Significant Differences		
	Derry-clare	Cam-pion	Woot-ton	Chapel-ton	P=0.05	P=0.01	P=0.001
% Males (Transformed data)	51.71	50.08	47.64	42.13	2.14	2.94	4.05

1.5 Soil Factors influencing P. loosi—A pot experiment was designed to determine the influence of different soils on the multiplication of *P. loosi*. Soils were collected from 8 estates and added to pots and left fallow for 4 months to reduce nematode numbers. Clone DT 1 was planted in the soils and approximately 2,000 nematodes from one source were added to each pot over a period of 3 months. Five months after the last inoculation, nematode numbers in tea roots were determined in one-third of the pots. Soil had a marked influence on the number of nematodes, the lowest being 22 per g root (Derryclare) and the highest 399 (Drayton). Two more counts will be made during 1965.

1.6 Control of P. loosi in the nursery—There is circumstantial evidence to indicate that water used in the nursery may carry nematodes from infested fields. Apart from siting nurseries away from infested areas, the use of settling tanks seems to be the most practical solution to the problem. In still water nematodes will settle on the bottom of a storage tank. This will be investigated in more detail in 1965 but preliminary observations were made on the rate nematodes sink in still water.

A 400 gallon tank, 4′ deep, was filled with water and a heavy suspension of nematodes (*P. loosi*) added. Every hour 100 ml samples were taken 12″ from the bottom of the tank by means of a syphon (Table 4). After 24 hours, 100 ml samples were taken at 6″ intervals down the depth of the tank (Table 5). Results show that after 24 hours no live nematodes were in the water taken 12″ from the bottom of the tank and that all living nematodes had sunk to the bottom.

TABLE 4—*Number of* P. loosi *in* 100 *ml samples taken 12″ from bottom of sedimentation tank 4′ deep*

Time after nematodes added (hours)	Living nematodes	Dead nematodes	Total
1	15	6	21
2	14	14	28
3	6	4	10
4	8	6	14
5	10	8	18
6	9	8	17
7	5	4	9
8	8	6	14
9	9	6	15
10	2	3	5
11	2	3	5
12	2	0	2
24	0	1	1

TABLE 5—*Number of* P. loosi *in 100 ml samples taken from different depths in sedimentation tank 24 hours after nematodes added*

Sample Depth	Living nematodes	Dead nematodes	Total
6″	0	1	1
12″	0	2	2
18″	0	2	2
24″	0	1	1
30″	0	0	0
36″	0	0	0
42″	0	2	2
48″	17	26	43

1.7 P. loosi in the Low country—All relevant evidence indicates that *P. loosi* causes damage to tea only on estates above 3,000 ft *P. loosi* has been recorded on several estates in the Low country, but until this year, nematode infestation has never been associated with damage. Recently on Dankoluwa Estate, Pitabeddera, damage to new clearings has been associated with eelworm infestation. It is possible, although unlikely, that a strain of *P. loosi* has become adapted to the high soil temperatures of the low-country, and to investigate this possibility, a simple pot experiment was started at St Joachim. In this experiment, the pathogenicity of *P. loosi* from Dankoluwa and from St Coombs will be compared. Results are not yet available.

2 *Meloidogyne brevicauda*

In July 1962, twenty one clones were planted on Oliphant Estate immediately after uprooting old tea that was heavily infected with *M. brevicauda*, the

root-knot nematode of mature tea. An unidentified clone (Nayabedde 3) is growing very well, followed by DT 95 and DT 1. The area is also infested with *Pratylenchus loosi* and it is possible that the good growth of these clones indicates resistance to *P. loosi*, rather than to *M. brevicauda*.

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REPORT OF THE ADVISER IN PLANT PATHOLOGY FOR 1964

A. Kerr, BSc, PhD

General

There were no staff changes during 1964.

Two hundred and nine estate visits were made during the year ; 226 letters were received and 267 sent. Three officers from other divisions received training in the identification of diseased specimens.

1 Blister Blight (*Exobasidium vexans*)

1.1 Fungicide Trial—In Field No 6 at St Coombs, nickel chloride hexahydrate and YF 6011, a copper and zinc oxide formulation, were tested at $\frac{1}{2}$, 1, 2 and 4 oz per acre and compared with a standard 50% copper fungicide (Perenox). Both test fungicides gave satisfactory control at 4 oz per acre. The Entomology division is comparing mite numbers on tea sprayed with nickel and with copper. Quality of made tea is being assessed by the Technology division and nickel residues are being determined.

1.2 Epidemiological Studies—Spores were caught in a Hirst spore trap in Field No 9 from April to December. High spore numbers were recorded in October (17,411 spores per cu m air) and in June (11,431) and low numbers in April (1,851) and in August (2,783). The highest levels of infection were recorded in July, November and August. Since 1962 when spore trapping was started, low spore numbers and relatively high infection levels have been recorded in August. It would appear that after prolonged monsoon conditions, sporulation is considerably reduced. High sporulation of individual blisters is associated with an average of more than 5 hours sunshine per day for 2 weeks, followed by rain.

Spore production by *Exobasidium vexans* is being studied in the laboratory and a suitable standardized technique has been developed.

1.3 Resistance of Clones—In collaboration with the Plant Propagation division, 31 clones were assessed on 3 separate occasions for resistance to Blister blight. Infection was assessed by determining the percentage of 2nd leaves infected. Results are given in Table 1. Twenty two of the clones were significantly more tolerant than seedling tea in all three assessments. There was a high correlation between percentage infection and the numbers of blisters per leaf.

1.4 The Infection Process—A study of the infection process has shown that spores germinate much more rapidly on the 1st leaf of tea shoots than on the 3rd leaf or on glass slides. The final percentage germination is similar on all three surfaces, but appressoria formation is markedly different, being 85%, 30% and 0% on 1st leaves, 3rd leaves and glass slides respectively. In addition to the nature of the surface on which germination occurs, appressoria formation is influenced by light. In darkness 88% of spores formed appressoria ; in light no appressoria were formed. Germination was only slightly less in the light. These results are similar to those obtained in studies on rust fungi (Lowell, Oliver & Wilcoxson, 1958). Six clones with varying resistance to *Exobasidium vexans* were inoculated with spores, but there was no significant difference in germination and appressoria formation on different clones, indicating that resistance is determined by internal factors, after penetration has occurred.

TABLE 1—*Incidence of Blister blight on different tea clones*

Clones		% Infection 1st Assessment	2nd Assessment	3rd Assessment	Average
Cannavarella	CV 5	1.29	1.29	11.79	4.8
,,	CV 5	6.05	3.08	8.08	5.7
Kenilworth	KEN 15/7	4.16	3.55	10.25	6.0
Craig	CR 4	4.56	4.21	10.75	6.5
Kirkoswald	K 136	7.46	2.79	15.39	8.5
,,	K 150	9.24	1.44	18.44	9.7
TRI	TRI 2024	7.43	9.40	12.14	9.7
Uva Highlands	UH 93	4.76	9.17	15.90	9.9
Thotulagala	T 5/3	3.82	7.06	19.74	10.2
Kenilworth	KEN 16/3	15.56	5.73	13.05	11.4
Tangakelle	CY 9	6.19	8.66	23.11	12.7
TRI	TRI 2151	10.72	7.55	20.90	13.1
,,	TRI 2027	3.78	8.40	27.36	13.2
Neluwa	NL 3/1	6.34	8.66	25.24	13.4
,,	NL 4/2	8.01	15.05	28.36	17.1
Balangoda	MT/BG 2/36	6.32	9.80	37.88	18.0
,,	MT 18	9.63	9.96	35.95	18.5
,,	DG 39	5.31	11.72	38.82	18.6
Talankande	TK 48	9.58	15.60	33.87	19.7
TRI	TRI 2025	5.55	10.68	43.46	19.9
,,	TRI 777	7.54	13.44	42.27	21.1
Thotulagala	T 5/35	15.06	16.00	38.31	23.1
Endane	EN 31	22.13	15.62	34.00	23.9
Queenstown	QT 1/5	10.23	19.58	42.36	24.1
Drayton	DT 1	8.01	16.42	49.35	24.6
Gonamotava	GMT 9	7.58	14.61	52.00	24.7
Diyagama	N	13.33	15.58	53.63	27.5
Poronuwa	PO 26	22.54	20.88	52.34	31.9
Passara	PA 22	21.79	24.32	54.10	33.4
TRI	TRI 2026	20.16	18.74	70.28	36.4
Seedling Tea		29.47	25.56	57.42	37.5
TRI	TRI 2023	14.18	31.12	67.90	37.7
Significant Difference P= 0.05		7.92	7.33	12.54	—

2 **Red Root Disease** (*Poria hypolateritia*)

2.1 Fumigation Trials on Estates

The 9 quarter-acre trials using 2,000 lb DD per acre have been completed. Results were assessed by using *Tephrosia vogelii* as an indicator crop. There was no residual infection on 5 estates indicating complete control up to a depth of approximately 20 inches (mean depth of *T. vogelii* roots). On one estate viable *Poria* mycelium was observed at one point, and on 2 other estates at 2 points, all on the perimeter of the treated blocks and probably the result of re-infection from adjoining infected tea. On one estate tea was planted shortly after fumigation and to-date, no infection has been observed.

These results confirm earlier findings that soil fumigation with DD can control *Poria*.

2.2 Field Experiments

2.2.1 *Longevity Tests*—Details of this experiment were given previously (Kerr 1964). After two years burial in soil, the fungus was still alive in all the 2 and 3 cm thick root segments and in half of the 1 cm thick segments. All the root segments were highly decomposed and very little mycelium was present. To determine if there was sufficient inoculum to infect healthy tea, potted plants were inoculated with the retrieved root segments. Results are not yet available.

A new experiment was started to determine if survival of *Poria* in infected roots is influenced by depth of burial in soil.

2.2.2 *Efficiency of different methods of sealing the soil surface after fumigation with DD*—Details of this experiment were given previously (Kerr 1964). The best treatment was (*a*) watered lightly and then covered with Guatemala grass loppings, followed by (*b*) covered with Guatemala grass loppings, both treatments being better than sealing the soil surface with polythene sheeting.

2.2.3 *Soil fumigation with Vapam and Methyl bromide*—During the year 3 further trials with Vapam were started on Kirimetiya, St John del Rey, and Templestowe estates. Results are not yet available.

In a field experiment on St Coombs, methyl bromide is being tested at the rate of 1, 2 and 4 lb per 100 sq ft of soil for control of *Poria* in artificially infected roots buried at 1, 2 and 3 feet. The standard treatment with DD (2000 lb per acre injected at 6 in depth) is also included for comparison. Results are not yet available.

2.3 Pot Experiments

2.3.1 *Resistance of Clones*—Examination of 23 clones eighteen months after inoculation showed that none were immune to *Poria*. Four clones, H 13/4, TRI 2016, TRI 2022 and TRI 2025 appeared to be highly resistant. A further 18 clones will be tested in 1965. The clones are CY 9, DT 95, DUN 7, E7/27, KM 247, KEN 16/3, MO 116, MO 208, NL 3/1, NL 4/2, TC 9, W 3, W 14 and TRI clones 425, 740, 2027, 2142 and 2151.

Fifty apparently healthy bushes in old *Poria* patches on Mattakelle estate were inoculated in June to assess their susceptibility to the disease. No symptoms are evident yet.

2.3.2 *Soil Fumigation*—The efficacy of DD in controlling 4 other root diseases, White Root (*Fomes lignosus*), Brown Root (*Fomes noxius*), Black Root (*Rosellinia arcuata*) and *Ustulina* (*Ustulina deusta*) is being studied. Results are not yet available. Other chemicals will also be tested.

2.4 Laboratory Studies

2.4.1 A technique has been developed to test rapidly in the laboratory soil fumigants for the control of *Poria* and other root diseases. Five fumigants, carbon disulphide, Dowfume W 85, Fumazone 70 E, Nemagon and WN 12 have been compared with DD Results showed that WN 12 was approximately 16 times more effective and carbon disulphide twice more effective than DD in killing *Poria*. The others were less effective than DD.

Tests also indicated that *P. hypolateritia*, *F. lignosus*, *F. noxius* and *U. deusta* are equally sensitive to DD whereas *R. arcuata* is more resistant.

2.4.2 *Mode of action of DD* — The role of the fungus *Trichoderma viride* in the control of *Poria* by fumigation with DD is being investigated. Results of early experiments showed that approximately 8 times more DD was required in sterile soil than in non-sterile soil to kill *Poria* in infected roots, indicating that *T. viride* plays a vital role in the destruction of *Poria* by DD.

3 Collar and Branch Canker (*Phomopsis theae*)

In comparative pathogenicity studies at high elevations in both field and glasshouse, *P. theae* was much more pathogenic than *Leptothyrium theae*, *Macrophoma theicola* and *Botryodiplodia theobromae*.

Field observations indicate that canker attacks are sporadic and vary in intensity from year to year and between localities. The disease is serious only in young plantings up to 8 years in age. Canker infections are associated with wounds on the collar and frame, and with nodes on young branches. There is a marked variation in clonal susceptibility and there are indications that drought and poor soil conditions are predisposing factors.

Field trials to determine the relative susceptibility of 20 clones have been started on St Coombs and Nayabedde estates and one on Glen Devon estate will be started in 1965. To determine which time of year is most critical for canker infection, 2 clones, TRI 2024 and NB 3, at Demodera and Nayabedde respectively, are being inoculated every month and at the same time bark and soil moistures are being measured. Inoculation started in October and no cankers are evident yet.

Two experiments are in progress to study the effect of "bending" as against "non-bending" on the incidence of collar and branch canker in young clonal tea. At Downside there were more cankers on the bent bushes (clone TRI 2024) and at Nayabedde there were more on the bushes not subjected to bending (Clone NB 3). On another clone (NB 13) at Nayabedde where the bushes were bent lightly there was no marked difference in the number of cankers in the bent and not-bent bushes. The experiments are being continued.

4 Oilspot disease

Inoculation of mature tea with the fungus always associated with oil spot has so far failed to produce any symptoms of the disease.

The rate of spread of the disease is being assessed on a plot of 1000 bushes on Pedro estate. Also on this estate an experiment is in progress to determine if pruning below infected wood induces healthy new growth. Definite conclusions cannot yet be drawn.

5 Black Blight (*Rhizoctonia solani*) in the Low Country

Six oz per acre of a 50% copper fungicide gave good control of the disease in the field.

The causal fungus has been isolated and pathogenicity experiments are in progress.

6 Maintenance Leaf Fall

An account of work on this disease has been published in the Tea Quarterly. A further large scale field trial has been started on St Joachim.

7 Stem Cankers in Clonal Tea in the Low Country

An account of this new disease has been published in the Tea Quarterly. A fungal pathogen does not appear to be the primary cause. Work has started to determine what factors are important and also to determine the rate of spread of the disease.

8 Red Rust (*Cephaleuros parasiticus*)

A laboratory study of the algal pathogen has been started.

9 Disease of Cover Crops and Shade Trees

9.1 Guatemala grass (*Tripsacum laxum*)—*Bacterial leaf stripe* (*Xanthomonas sp*) Preliminary experiments indicate that the causal bacterium does not attack sugar cane.

9.2 Gums (*Eucalyptus robusta*) *and Acacia* (*A. decurrens*)— In March young gums and Acacias were affected by a canker disease in a nursery at Halgranoya and a few plants died. Isolation and inoculation experiments showed that the cankers were caused by *Cercosporella theae*. This is a rare occurrence.

9.3 Gliricidia maculata—Inoculations with a fungus (probably *Xylaria* sp.) isolated from trees showing severe chlorosis and defoliation in the Low country have not been successful. The cause of this trouble is still not known.

10 Miscellaneous

10.1 Decay of shade trees stumps—In collaboration with the Forest Research Laboratory, the rate of decay of *Grevillea robusta* wood by *Polystictus sanguineus*, *Lentinus giganteus* and 3 other unidentified wood-rotting fungi was determined by the standard Kolle Flask method. Only *P. sanguineus* and *L. giganteus* caused rapid decay of *G. robusta* wood. These two fungi will be tested on *Grevillea* stumps on tea estates. More wood-rotting fungi are being tested in the laboratory.

10.2 Effect of lime-washing on bud-break—An experiment was carried out on No 3 Field, St Coombs, to determine the effect of lime-washing after pruning on subsequent bud-break. The tea was pruned and the frames cleaned by hand and then one half of the area was sprayed with limbux (1½ cwt per acre) and one half left untreated. Three bud counts were made on randomly selected bushes 7, 9 and 12 weeks after pruning. There was no significant difference in the number of buds counted on sprayed and unsprayed bushes. The experiment is being repeated on another field.

11 Visits and Lectures—Dr R. L. de Silva read a paper at the Ceylon Association for the Advancement of Science on "The role of pectolytic and cellulolytic enzymes in the infection of young seedlings by *Corticium solani* Prill and Delacroix (Bourd and Galz) and *Corticium praticola* Kotila". A paper by Dr R. L. de Silva and Prof R. K. S. Wood on "Factors affecting the specificity of parasitism by *Rhizoctonia solani*" was read at the British Mycological Society Symposium on "The Biology of Infection".

Publications

DE SILVA, R. L. and WOOD, R. K. S. (1964) Infection of plants by *Corticium solani* and *C. praticola*—Effect of plant exudates. *Trans. Brit. mycol. Soc.* **47:** 15-24.

DE SILVA, R. L. (1964) Stem cankers in clonal tea in the low country. *Tea Quart.* **35 :** 196-199.

SHANMUGANATHAN, N. (1964) Recent developments in the control of *Poria* root disease. *Tea Quart.* **35 :** 22-31.

SHANMUGANATHAN, N. and REDLICH, W. W. (1964) An experiment on the control of maintenance leaf fall by certain sanitary measures. *Tea Quart.* **35 :** 200-203.

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ROWELL, J. B, OLIVER, and C. R. WILCOXSON, R. D. (1958) Effect of certain environmental conditions of infection of wheat by *Puccinia graminis*. *Phytopathology* **48 :** 371.

REPORT OF THE ENTOMOLOGIST FOR 1964

J. E. Cranham, BA, DIC, MI Biol

1 General

Mr K. Thirugnanasuntharan, joined the staff at Hantane in January, as Technical Assistant. Mr E. F. W. Fernando was promoted to the grade of Senior Technical Assistant. Mr H. H. Samarakoon, who had been seconded to the Entomology Division for training, was transferred to the Low Country Station at St Joachim in June. Estate visits by staff numbered over 150 and were mostly in connection with research trials. There were 483 letters received and over 660 sent out.

2 Shot-hole Borer

2.1 The design and previous results of these trials have been described in earlier reports. (Cranham, 1962, 1963, 1964a). Six of the trials on four-year cycles were completed during 1964, and this concludes this series of trials started in 1960-1961 except for one remaining trial on Balangoda Group. The fourth-year data of these trials give further useful evidence on the environmental factors regulating borer numbers, and on the value of post-pruning sprays of dieldrin in longer cycles, and it is now possible to define general conclusions.

On the unsprayed plots, the results show that the population left in the pruned frames declined in the ensuing months. The population then increased in the new wood to a major peak of attack which usually occurred in the late second year or early in the third year after pruning, and numbers then declined markedly. There tended to be a further rise in the late third year but this was generally much smaller than the second-year peak.

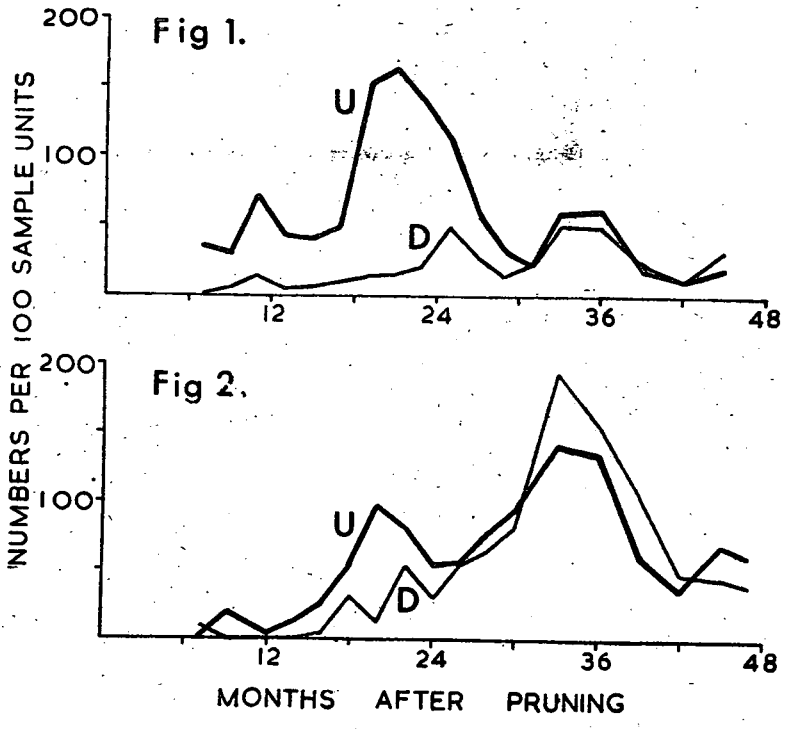
On the average counts, dieldrin gave good control up to 24 months from spraying; the average count of galleries was reduced by more than two-thirds. The crucial point was whether spraying would merely postpone the peak of attack by a few months. In fact, the delay in build-up on the sprayed plots resulted generally in a much reduced peak attack, on an average about half that which occurred on the unsprayed plots a few months earlier; this was followed by a decline which was generally synchronous with the latter part of the population decline on the unsprayed plots. Thereafter, from about the 30th month, the infestation and gallery density showed similar levels and trends on both the sprayed and the unsprayed plots; there was usually a small increase towards the end of the third year followed by a decline into the fourth year. The peak of this gradation was much smaller than the second-year peak of attack in all trials except the Meddecombra trial. Figures 1 and 2 illustrate this point; the results on the Uva Ketawella trial (Figure 1) are fairly typical of five of the six trials that ran for four years; only at Meddecombra (Figure 2), where the second-year peak was unusually low, was there a higher peak of attack in the late third year.

The data now gathered over four years show that there tends to be a series of more or less annual gradations (rises and falls) in population, which appear to be synchronised to a marked degree by seasonal weather changes in both the NE and SW monsoon zones. Further study is required to determine which climatic factors are most influential and whether their action is mainly direct, or indirect through their effect on the growth of the host plant. So far it appears that prolonged rainfall periods render conditions less suitable. The

phases in growth of population start in the drier period of the year, or towards the end of that period, in both the SW and NE monsoon zones; but the trends in various trials were somewhat conflicting and it is possible that very prolonged dry weather may also render conditions less suitable. Optimum conditions may lie between the seasonal extremes.

The major factor limiting population growth appears to be the suitability of the host plant and the availability of wood suitable for gallery formation and brood rearing, and presumably for the growth of the ambrosia fungus, the sole food of the larvae. The borer prefers young wood, and pruning itself periodically recreates abundant young wood, free of old galleries. In heavy attacks the infestation develops to near the limit of the available 'resource' of suitable wood, to a 'saturation density' of galleries, usually between 100-150 galleries per 100 sample units. The effect of accumulated attack is progressively to deplete the available wood and to render conditions less suitable as the gallery density rises.

Study of the frequency distribution of galleries on the four-inch sample units used, shows that the distribution was more uniform than random (variance less than the mean) and the uniformity tended to increase as the gallery density increased. This suggests that, in effect, there are a limited number of suitable spaces for gallery formation and that parent female beetles have a marked capacity to avoid those already used.



FIGURES 1 & 2—*The trends in infestation (number of live borers per 100 sample units) on the unsprayed (U) and dieldrin-sprayed (D) plots over the pruning cycle in the Uva Ketawella (Figure 1) and Meddecombra (Figure 2) trials.*

Generally, the heavier the second-year peak of attack, the more marked was the decline that followed, and this decline often occurred during a period which appeared to be climatically favourable for increase, judging from the continued growth of population on the sprayed plots which carried lower densities. With the decline of fresh attack after the heavy peak, the bushes

get a chance to recover, and in healthy bushes the recovery and growth is marked and results in a thickening of thin unattacked stems, and the gallery density falls. Thus the resource of wood available for attack is partially restored and infestation rises again towards the end of the third year and then again declines. This third gradation was usually much smaller than the second gradation and the reproductive rate (as judged by the proportion of young in the population) was generally much lower than earlier in the pruning cycle. This suggests that conditions in the host plant may, as Gadd (1949) supposed, usually become less suitable with age from pruning; although not always, as exemplified at Meddecombra.

From the aspect of practical control, it is of major significance that conditions are not continuously favourable for increase and the innate capacity for increase of this pest is small compared to many others. Borer numbers are relatively low in the first year and, in most cases, from the 30th month onwards in longer cycles. The reduction of the major peak attack between the second and early third years is the main aim of control measures. If this can be achieved, then in most cases any attack that develops later, in the third and fourth years, will be less serious. Although the control achieved by post-pruning sprays is often partial; yield trials show that it results in considerable benefits to the health and yield of the bushes. Also, it may sometimes be possible to lengthen the pruning cycle whilst maintaining the yield level; in a 3 or 4 year cycle the period of serious borer attack is a smaller proportion of the whole cycle than in a 2 or 2½ year cycle. In the low country, where 18-month cycles have become popular because of serious borer attack in the 18-24 months after pruning, the return to two-year cycles made possible by control can have striking advantages (see report on Endane Manurial Trial, Cranham, 1964a; Fernando, 1964).

2.2 Trials on the effect of control on yield and fertilizer response

Trials of randomized block design—The results, for the first pruning cycle, of the three trials at Hantane, Bandarapola, and Kirimetiya Estates were reported previously (Cranham, 1963,1964). These trials were pruned in 1962 and were continued on a second cycle. Kirimetiya was pruned again in 1964. Hantane will complete a 3-year cycle in 1965. The cycle at Bandarapola was extended from two years to three years into 1965. In the second cycle, in order to study the effect of borer control on the yield response to fertilizer, two levels of NPK fertilizer (T725 or T750 mixtures) were introduced into each trial. These levels corresponded to 40 lb and 80 lb of nitrogen per acre per annum at Hantane and Kirimetiya, and 80 lb and 120 lb in the higher-yielding Bandarapola trial.

At Bandarapola, the infestation was higher than in the first cycle, with a peak difference of 77 adult beetles per 100 sample units in the 18th month. The increase in yield on the sprayed plots was correspondingly larger. Table 1 shows the yields expressed in lb of made tea per acre per annum and also as percentages compared with the yields of the unsprayed 80 lb N plots equal to 100%. With the poor replication of this trial, only the mean differences between the sprayed and unsprayed plots were significantly different, for the second and third-year periods and for the whole cycle up to the 30th month. However, the third-year data suggest a much improved response to fertilizer on the sprayed plots compared with the unsprayed and this difference may prove to be significant for the whole of the third year. This is a similar result to that obtained in the Endane fertilizer trial in 1962, and it is notable that the differences begin to emerge late in the pruning cycle. So far, the most important feature of the results is that the significant improvement in yield due to dieldrin spraying (average of 22% over the cycle) was much greater than that due to fertilizer equivalent to 40 lb extra nitrogen (average of 7% over the cycle).

TABLE 1—*The effect of control of Shot-hole Borer on yield and fertilizer response*

Bandarapola trial—Yield of treatments expressed as lb of made tea per acre per annum for the cycle (to 30th month)

	Yield	Increase	Percent comparison
Dieldrin-sprayed			
120 lb N	1146	265	130.1%
80 lb N	1087	206	123.4%
Unsprayed			
120 lb N	953	72	108.2%
80 lb N	881	—	100%

NB—The average yields for sprayed and unsprayed plots are significantly different (P=0.05)

Hantane trial — Yield of treatments (adjusted by analysis of covariance) expressed as lb of made tea per acre per annum, for the period of the 7th-27th months

	Yield	Increase	Percent comparison
Dieldrin-sprayed			
80 lb N	779	182	130%
40 lb N	729	132	122%
Unsprayed			
80 lb N	667	70	112%
40 lb N	597	—	100%

Significant difference (P=0.05) = 116 lb

At Hantane, the infestation on the unsprayed plots was lower than in the first cycle, with a peak difference between sprayed and unsprayed plots of 57 adult beetles per 100 sample units in the 15th month as compared with 111 beetles in the first cycle. Infestation was probably lower because of the extensive dieldrin spraying on this estate. The 500 bush plots used in the first cycle were reduced to 200 bush plots for the second cycle; the yields for the first three months (4-6 months) were used as a pre-assessment period of the individual plot yields, and analysis of covariance showed a very highly significant correlation with the later yields from the 7th to the 27th month. The adjusted yields for the later period, expressed as lb of made tea per acre per annum, are given in Table 1. The average difference due to dieldrin spraying was significant and a 19% increase over the cycle. The yield response to 40 lb extra nitrogen was similar on the sprayed and the unsprayed plots, averaging a 9% increase over the cycle which was not significant at the 5% level of probability.

In the Kirimetiya trial, infestation on the unsprayed plot was only light. The differences between sprayed and unsprayed plots, and those due to fertilizer dosage, were small and not significant.

Demodera trial—The Demodera trial completed a 45-month cycle in 1964. The attack on the sprayed and unsprayed plots was of a similar low level and followed similar trends in the fourth year. In the nine months of the fourth year the yield increase on the sprayed plots was a non-significant 4.2% (compared with 8.5%, 25.4% and 22.5% in the first, second and third years respectively). Although by the middle of the third year the infestation and gallery counts on the sprayed and unsprayed plots were of a similar low order, the effect of the much heavier attack which occurred earlier on the unsprayed plots appeared to be carried over into the third year; presumably because it takes time to repair the damage, particularly stem breakages, caused by the borer. The yield increase on the sprayed plots was almost as large in the third year as in the second year; but by the fourth year it would appear that the effects of the earlier heavy attack no longer affected the yield appreciably.

2.3 Alternative insecticides

Trial work continued on the use of Telodrin and aldrin, compared with Dieldrin, as post-pruning sprays in mature tea and on the use of aldrin as a 'mid-cycle' spray.

(*a*) *Post-pruning sprays*

The series of eleven field-scale trials initiated in late 1962 and in 1963 (Cranham, 1964) were continued through 1964. Only one of the trials (Gallebodde) has as yet run for two years from pruning and several of the trials have run for only 15 months and on the evidence of these trials, it is not yet possible to revise recommendations. The following tentative conclusions can be reported.

Results so far suggest that aldrin (at 6 pints of 20% EC per acre) will not give control of as long a duration as that obtained from dieldrin, and aldrin will probably not be satisfactory as an alternative for dieldrin. It may possibly be suitable for the short pruning cycles of 18-24 months practised in the low country. Aldrin costs somewhat less (6 pints costs about Rs 22/50 at current prices) than dieldrin; also the Tortrix side-effect is much less than with dieldrin and in many cases spraying against Tortrix should not be necessary.

Telodrin on the other hand so far looks promising at the low dosage of 2 pints 15% EC in 70–100 gallons of water per acre; and shorter-term trials suggest that even 1 or 1½ pints may do well. If such low dosages of Telodrin are effective, (1) it would greatly reduce the cost of chemical per acre (1 pint costs about Rs. 8/50) and (2) the liability to Tortrix outbreaks should be appreciably less than when using dieldrin and in many cases spraying against Tortrix should not be necessary.

The only disadvantage foreseen is the high mammalian toxicity of Telodrin, which is 8-10 times that of dieldrin. In respect of this, it is felt that (1) at the low concentration dosage of 1 or 1½ pints in 70-100 gallons of water, the hazard to spraying labourers should not be very different from that of 6 pints of dieldrin 20% EC in the same dilution, and (2) there will be an increased hazard in handling the Telodrin 15% concentrate. The toxicological aspect is being investigated and no recommendation can yet be made.

(*b*) *Mid-cycle sprays*

Six trials on estates were initiated in 1964 to test aldrin as a mid-cycle spray *ie* a spray applied to the lower parts of the bush frames when the bushes are in full foliage, at some time during the pruning cycle. The main interest

at present is focussed on spraying about one year after pruning in order to avert the major second-year build-up of borer attack. The possible advantages of Aldrin for this purpose have been given previously (Cranham, 1964).

Trials were started at Sogama (2 trials), Blackwater (2 trials), New Peacock and Moolgama estates, employing treatments of aldrin 20% EC at 6 pints and 3 pints in 70-80 gallons of water per acre. In order to obtain results under practical estate conditions, the supervision of spraying was carried out by the estates. So far, results are inconclusive except at New Peacock where the control from 6 pints of aldrin is very good, confirming earlier results at Carolina estate.

This method of spraying should be practical on a large acreage of mid-country and low country tea. It is usually possible to time spraying so that it is done just before the monsoon, so that the months after spraying fall in a weather period when conditions are unfavourable for a build-up of Tortrix; this, combined with the less severe effect on *Macrocentrus* of aldrin compared to dieldrin, may succeed in averting any serious Tortrix attack in most cases. In fact, in these six trials, only one trial (at Blackwater) required spraying against Tortrix, and here the occurrence of Tortrix on the 3-pint aldrin plot and not on the 6-pint aldrin plot suggested that it was not primarily due to aldrin spraying.

Previous work assessed the residues of aldrin and dieldrin in made tea occurring at intervals of 1, 2, and 3 weeks after a full-foliage spray of aldrin at 4 and 8 pints of aldrin 20% EC per acre; analyses of tea samples was carried out at the Shell Woodstock Agricultural Research Centre, England (Cranham, 1964). The results show that in order to avoid residues which might result from chance contamination of the plucking table when spraying the lower parts of the bush frames, a 'safe period' of three weeks between spraying and plucking should be adequate. Accordingly this period was used in these trials and samples from the first manufacture, about three weeks after spraying, were sent for analysis. The highest residue found was 0.05 ppm of dieldrin; dieldrin is involved because a small part of the aldrin is epoxidised to dieldrin (SICC Ltd, 1963). Thus, a 3-week safe period should be a completely adequate safeguard; especially as bulking of the made tea will normally reduce this very low level of residues still further.

(*c*) *Relative activity of Aldrin and Dieldrin*

The relative activity of dieldrin and Telodrin was compared in an earlier detailed trial (Cranham, 1964) and it was required to make a similar detailed comparision of the activity of aldrin and dieldrin. A trial was started in March on a clonal new clearing at Moolgama Estate, Panwilatenna, and involved six randomized blocks of eight 100-bush plots. Since previous evidence suggested that these insecticides have a similar potency, both were applied at rates of 8, 4, and 2 pints of the 20% EC's in 100 gallons of water per acre applied by knapsack sprayers *ie* dosages equivalent to 2, 1, and 0.5 lb of active insecticide per acre. There were two untreated plots in each block. Sampling of Shot-hole Borer was carried out at 4, 8, 16 and 29 weeks after spraying; 25 sample units were taken from each plot on each occasion.

TABLE 2—*Moolgama (1964) trial: the comparative toxicity of Aldrin and Dieldrin to Shot-hole Borer*

TREATMENT	Numbers of adult beetles (and immature stages in brackets) per 100 sample units after (weeks)				
	Precount	4	8	16	29
Aldrin, 2 lb	219(317)	24(21)	8(4)	3(0)	5(5)
Aldrin, 1 lb	214(241)	14(3)	10(21)	9(1)	8(17)
Aldrin, 0.5 lb	219(329)	47(53)	15(16)	18(1)	18(33)
Dieldrin, 2 lb	219(241)	29(22)	7(3)	1(0)	3(3)
Dieldrin, 1 lb	224(321)	29(47)	7(2)	5(4)	5(4)
Dieldrin, 0.5 lb	266(333)	33(34)	12(1)	6(3)	4(2)
untreated (avg)	238(339)	103(140)	44(50)	22(7)	18(31)

Table 2 gives the counts of numbers of live adults and immature stages expressed in numbers per 100 sample units. The high initial infestation exemplifies that commonly occurring in clonal tea. On the 4-week and 8-week counts, all treatments showed significantly lower counts than the untreated plots. The data illustrate the reduction within the first few weeks after spraying, as shown in earlier trials at Downside and Craigie Lea (Cranham, 1962). Unfortunately the infestation on the unsprayed plots also declined, more slowly but markedly by the 16th week; presumably beetles in the dispersal phase are affected by the surrounding sprayed plots. This type of effect may also reduce differences between treatments in a trial with small plots of 100 bushes.

There were no significant differences between insecticide concentrations. The general mean values for aldrin and dieldrin were rather similar throughout except that there were significantly more live young on the aldrin plots in the 8 and 29 week counts, mostly on the lower dosages of aldrin. There was thus no evidence that aldrin and dieldrin differed in their initial effect but there was a suggestion that the effect of aldrin at the 1 and 0.5 lb dosages was less complete afterwards, possibly due to the lower persistence of aldrin. This agrees with general indications from the longer-term trials on large plots.

3 Tea Tortrix

3.1 Incidence on unsprayed tea

In late 1963 and the early months of 1964, reports were received from various districts of an increased incidence of serious outbreaks of Tea Tortrix on tea not sprayed with dieldrin. The question posed was whether this was due to the more widespread adoption of dieldrin for borer control. Visits were made to a few estates and it was decided to carry out a survey of the problem by questionnaire. This survey eventually covered all estates in the planting districts of Uva, Pussellawa, Kandy, Hewaheta, Dimbulla, Dickoya and Sabaragamuwa; about two-thirds of the estates replied and the survey produced some valuable facts concerning the problem.

As far as present knowledge goes, the major natural factors which regulate Tortrix numbers include the parasite (*Macrocentrus homonae* Nixon) and also certain diseases of the larvae which include a virus disease (wilt) and a fungus disease; mortality due to the diseases is much higher in wet weather. Weather appears to have a major effect on the incidence of the pest, either directly or indirectly through other factors. The maintenance of Tortrix at low numbers is brought about not just by one factor but by the combined effect of several factors. There are sound reasons to suppose that the numbers of Tortrix, like a number of other pests, fluctuate through successive cycles of years of high incidence and low incidence. Judging from our records, there has been an increasing number of outbreaks in upcountry districts starting from about 1956-1957, that is, long before dieldrin spraying was started; these were more frequent than ever in 1963 and 1964. In 1964 the incidence in Dimbulla and Dickoya was quite as bad as in Pussellawa and Badulla sub-districts where Dieldrin spraying was fairly intensive.

Tortrix is more of an upcountry pest; 'natural' outbreaks occur usually above 3,000 feet, and the present distribution on unsprayed tea has been more towards the higher elevations. In Pussellawa, seven out of eleven estates which had outbreaks on unsprayed tea had not carried out any dieldrin spraying. Conversely, in the Gampola and Kandy districts, where dieldrin spraying was much more intensive, there was very little Tortrix on unsprayed tea. Similarly the incidence was higher in Badulla than at the lower elevations in Passara, although both districts carried out intensive dieldrin spraying. The incidence in Sabaragamuwa was relatively low.

TABLE 3—*Some results of the survey by questionnaire on the relation between intensity of dieldrin spraying and the occurrence of serious Tortrix attack on unsprayed tea*

District	No of estates doing dieldrin spraying out of the number which replied; percentage of tea acreage sprayed	No of estates which reported serious Tortrix outbreaks on unsprayed tea; and the total acreage of tea reported as badly attacked
Uva		
Badulla	16(23) :14.2%	11 : 1069 acres
Passara	15(24) :16.1%	4 : 71 acres
Haputale	6(27) : 5.2%	2 : 327 acres
Pussellawa		
Pussellawa	8(16) : 6.7%	11 : 1703 acres
Gampola	10(10) : 18.0%	3 : 202 acres
Kotmale	7(8): 11.5%	5 : 200 acres
Dolosbage	5(10): 7.7%	8 : 399 acres
Kandy (including Matale & Madulkelle)	13(20) : 13.1%	2 : 70 acres
Hewaheta	3(10) : 4.7%	3 : 81 acres
Dimbulla	9(59) : 2.0%	32 : 2656 acres
Dickoya	17 (57) : 5.5%	28 : 2500 acres
Balangoda	4(12) : 5.0%	0 : nil
Ratnapura	10(18) : 13%	1 : 80 acres
Rakwana-Deniyaya	5(8) : 5%	0 : nil

As shown in the data of Table 3, the incidence on unsprayed tea has not been linked particularly with dieldrin spraying. It does not seem in anyway plausible that dieldrin spraying in the mid-country, on the rather limited scale so far carried out, can have affected the upcountry districts. Naturally, dieldrin spraying will aggravate the situation locally when the natural incidence of Tortrix is high and there can be little doubt that it has aggravated it on certain estates in the Pussellawa and Badulla sub-districts.

The extent of dieldrin spraying in the mid-country and low-country distticts badly affected by Shot-hole Borer (including Pussellawa, Uva, Sabaragamuwa and Kandy in the survey) has increased steadily as follows:

1961	—	2.4% of acreage
1962	—	5.0% of acreage
1963	—	8.0% of acreage
1964 (Sprayed and planned)	—	10.3% of acreage

Assuming the average pruning cycle is 3 years, the maximum proportion of the acreage that could be sprayed annually is about 33%, but not all the tea will merit spraying.

When dieldrin was initially recommended in 1961 on the basis of the large-scale trials carried out, a notable feature of the trials was the way in which Tortrix was very largely confined to the sprayed areas. The possibility was realised that as the scale of dieldrin spraying increased, the effect on the parasite throughout a whole district might be intensified. This could be determined only by the practical experience of spraying on a full scale; also it was reasonable to suppose that it might not happen because spraying would be carried out on a limited acreage of scattered fields and not on large continuous areas at one time. It is now evident that the liability to Tortrix outbreaks after dieldrin spraying has increased. In the original series of field-scale dieldrin trials, serious outbreaks occurred in about half the trials. In a more recent series of trials, serious attacks occurred on all the dieldrin plots and quite often on the adjacent unsprayed plots as well. Further, in certain districts, about half the number of dieldrin-sprayed fields on estates had to be sprayed twice with DDT or Dipterex, and a few three times, during 1963-4.

Probably both the increased scale of dieldrin spraying and the higher natural incidence of Tortrix have contributed to the increased severity of this unwanted side-effect; and it is not possible on the present evidence to assess the relative importance of these two contributory factors. It is clear that although the control of the borer has generally proved to be abundantly worthwhile, the Tortrix side-effect has in some districts become more than a nuisance and prejudices the more extensive use of dieldrin.

3.2 Chemical control

Two trials were carried out to assess the control of Tortrix obtained from a number of insecticides (new to Ceylon) as possible alternatives to DDT and Dipterex (trichlorfon). These included three insecticides related to DDT (Perthane, 'Rhothane' (TDE), and methoxychlor), the carbamates 'Sevin' (carbaryl) and 'Matacil', and the organophosphate 'Folithion' (fenitrothion). Of these, Perthane and 'Folithion' were of particular interest because in trials to assess their effect on mite numbers they did not increase the numbers of Red Spider Mite and Scarlet Mite. None of these insecticides showed exceptional promise but the results were not conclusive and it is planned to carry out further work.

4 Mites

4.1 The effect of insecticides on mite numbers

The results of earlier trials to assess the effect of insecticides on the numbers of mites in tea have been given in previous annual reports (Cranham, 1962, 1963, 1964). It is clearly of the utmost importance that insecticides used for the control of various insect pests of tea should not increase the incidence of the injurious mites. Conclusive results have been obtained on the effect on Scarlet Mite of the commoner insecticides in use, but a further opportunity was needed to study their effect on ea Red Spider Mite (*Oligonychus coffeae* Nietn). A trial was started on Welimada Group in April 1964 involving six randomized blocks of ten 100-bush plots. Applications were made by knapsack sprayers in 100 gallons of water per acre of the following treatments at the given dosages per acre: DDT 25% EC at 6 pints; Perthane 50%EC at 3 pints; 'Rhothane' (TDE) 50% WP at 4 lb; methoxychlor 50% WP at 4 lb; 'Sevin' (carbaryl) 85% WP at 2 lb; 'Matacil' 80% WP at 2 lb; 'Dipterex' (trichlorfon) 80% SP at 2 lb; and 'Folithion' (fenitrothion) 50% EC at 3 lb. Each block contained two untreated control plots. Treatments were sprayed on the 21st April and repeated, to intensify effects, on 6th July. Sampling was carried out before spraying and at monthly intervals after spraying for six months; two samples of 50 leaves were taken from each plot and the numbers assessed using the mite-brushing machine.

TABLE 4—*Welimada Group (1964) Trial: the effect of insecticides on Red Spider Mite numbers*

Insecticide (lb active per acre)	Mean* no. of mites per 100 leaves (600 counted) after (months) : 1 May	2 June	3 July	4 August	5 September	6 October
DDT	24	1099***	1286***	1047**	142*	19
Perthane	11	202	322	328	58	6
TDE	22	690***	1698***	902*	82	9
Methoxychlor	30	1362***	4468***	2234***	226***	22
'Sevin'	51	1300***	1824***	971*	83	10
'Matacil'*	11	273**	703**	636	110	10
'Dipterex'	10	154	551*	222	77	9
'Folithion'	6	103	134	193	50	11
Untreated (avg.)	8	93	238	163	50	10

**Antilog of mean log number; analysis of variance on log (n+1) values. The significance of differences from the untreated control values is shown by asterisks: *significant, **highly significant, ***very highly significant.*

Bayer 44646-3-methyl-4-dimethylaminophenyl-N-monomethyl-carbamate.

The counts obtained are given in Table 4. Treatments 2, 3 and 4 are insecticides closely related to DDT; it is of interest to note that TDE and methoxychlor increased the numbers of Red Spider Mite in a similar fashion to DDT, in fact the methoxychlor counts (in wettable powder form) were significantly higher than for any other treatment; for Perthane on the other hand the numbers were similar to the control counts and not significantly higher:

Dipterex showed a significant two-fold increase at three months after spraying. Only Folithion and Perthane did not show increases. Of the materials of proven value for Tortrix control, Dipterex had only a small effect and Sevin was as bad as DDT for increasing red spider numbers.

4.2 Activity of Acaricides

A new acaricide, Acricid (binapacryl) as a 25% WP (Messrs Hoechst AG, W. Germany) which has shown promise against tea mites in India, was compared with Kelthane (dicofol), in a replicated trial at Welimada Group. 2 lb of Acricid WP gave similar control of Red Spider and Scarlet mites to 0.75 pints Kelthane 36% MF, but 1 lb Acricid gave inferior control.

At Loinorn estate, the control of Scarlet mites by mistblower applications of Kelthane MF (0.75 pints in 10 gallons water per acre) was checked on large plots. A single application gave an excellent degree of control for the whole of the drier months (December to May).

Acknowledgements

The co-operation of estate superintendents and Colombo agencies, in offering facilities for the trials on control of Shot-hole Borer and on mite numbers, is gratefully acknowledged.

The Technology Division co-operated on the manufacture of samples of made tea for aldrin residue tests and thanks are again due to Messrs Shell International Chemical Co Ltd for analysis of the samples.

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REPORT OF THE ENTOMOLOGY RESEARCH OFFICER

HANTANE SUB-STATION, FOR 1964

D. Calnaido, BSc, PhD

The Ecology of Shot-hole Borer

1 *Flight and dispersal of Shot-hole Borer*

The flight and dispersal of Shot-hole Borer were studied by sampling with a vertical series of 5 suction traps in a tea field and by observations both in the laboratory and in the field (Calnaido, 1964).

1.1. Flight behaviour

Adult beetles emerging from galleries are positively oriented towards light. Around mid-day, they come out of their galleries, walk up tea stems, spread their wings once or twice and take-off upwards, in a slow fluttering flight. The fluttering appearance of flight is due to the beat of their elytra. They do not "flit" or "hover" over the crop nor do they show repeated flights, following alightment. The flight periodicity is determined by the numbers of beetles emerging from galleries in tea stems and taking off (Figure 1). In an infested field, at the end of its 2nd year from pruning, about 5 thousand borers emerge, per day per acre, and of this number over 50% fly away.

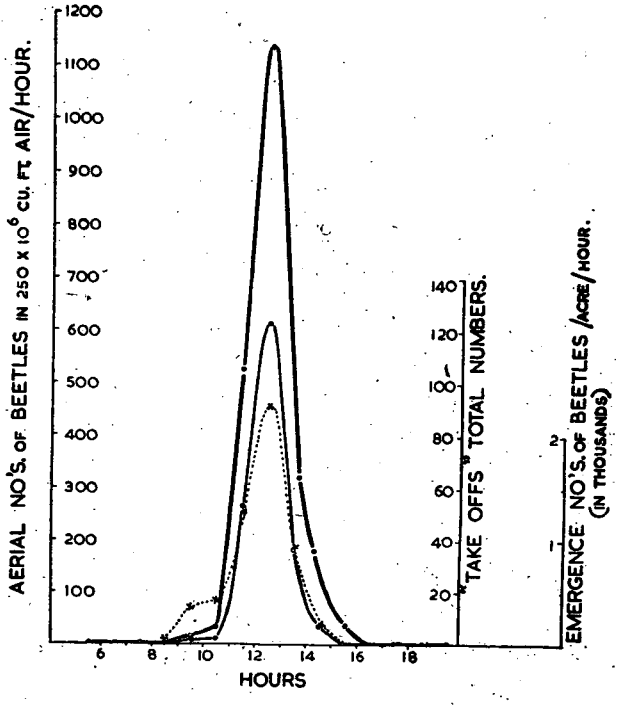

FIGURE 1—*The pattern of daily activity of Shot-hole borer. The broken line shows the numbers of beetles "emerging" from galleries in tea; the thin unbroken line shows the numbers taking off and the thick unbroken line shows the integrated total aerial numbers in flight*

1.2 The influence of weather factors on the flight

An analysis of the numbers of beetles caught in flight in the suction traps, and the weather factors indicate that the flight of the beetle is related to temperature and wind-speed. Increases in temperature and wind-speed appear to encourage aerial dispersal.

The analysis of data collected to-date also suggests that *Xyleborus fornicatus* has a lower flight threshold of 65°F (18.3°C) and a less defined upper threshold for flight of 87°F (30.6°C), while the arbitrary optimum for flight is between 75°F and 82°F (23.9° to 27.8°C). These flight thresholds provide an added explanation of the distribution of the pest in Ceylon (Calnaido 1964b).

More data on numbers in flight and simultaneous records of emergence and the weather factors, of temperature, rainfall, wind speed and sunshine, are being processed to obtain precise information on the influence of these factors on the flight activity of the beetle.

1.3 Flight velocity and duration

The free flight capacity of the borer was measured in the limited environment of the laboratory. The conservative estimates obtained indicate that the Shot-hole Borer's free flight velocity is 1 to 2 ft per sec (0.7 to 1.4 mph = 0.3 to 0.6 m/sec). The maximum duration of flight recorded was 24 minutes, but it is believed to be more than this on account of the limited conditions under which it was measured.

1.4 Flight muscles

The fact that the beetles usually live within the galleries in tea stems and do not fly when taken out of them may have contributed to the previous opinions about the flight of the borer (Gadd 1941). However, when infested tea branches were left for 3 to 4 days, large numbers of adult beetles emerged from the galleries and flew away. Further, dissections showed that beetles taken from galleries possess reduced flight muscles, while those caught in flight had fully developed flight muscles (Calnaido 1964). It is suspected therefore, that in *X. fornicatus* there is perhaps both autolysis and regeneration of flight muscles, as in some other Scolytidae (Atkins & Farris 1962), which could bring about re-emergence and second flights. This aspect of the problems is being investigated, as it has a direct bearing on the dispersal of the borer.

1.5 Dispersal

These studies on the 'emergence' and flight behaviour conclude that *X. fornicatus* is a migrant, in which the flight habits are an evolved adaptation for aerial dispersal. Much evidence suggests that Shot-hole Borer behaves like other migrants. The density on height profiles (Figure 2) are similar to those of Aphids (Johnson *et al* 1962) and Frit-fly (Calnaido *et al* 1964), though the general height of flight is much lower. The diurnal curves of 'emergence' from the crop, 'take-off' and flight (Figure 1) are all similar in slope and indicate how the sequence of these events may lead to dispersal. These aspects of the borers' flight, their flight behaviour, flight velocity and duration of flight, suggest that large numbers of young *X. fornicatus* adults launch themselves into the air, *en masse*, in an exodus flight, oriented towards light and fly upwards. They then drift in air currents, greater than their own weak flight speeds and are distributed away from their source, eventually to seek new habitats and new hosts. These results reveal that *X. fornicatus* is subjected to considerable aerial dispersion and that the borers could be widely scattered, particularly because they fly most around noon, when atmospheric instability is greatest.

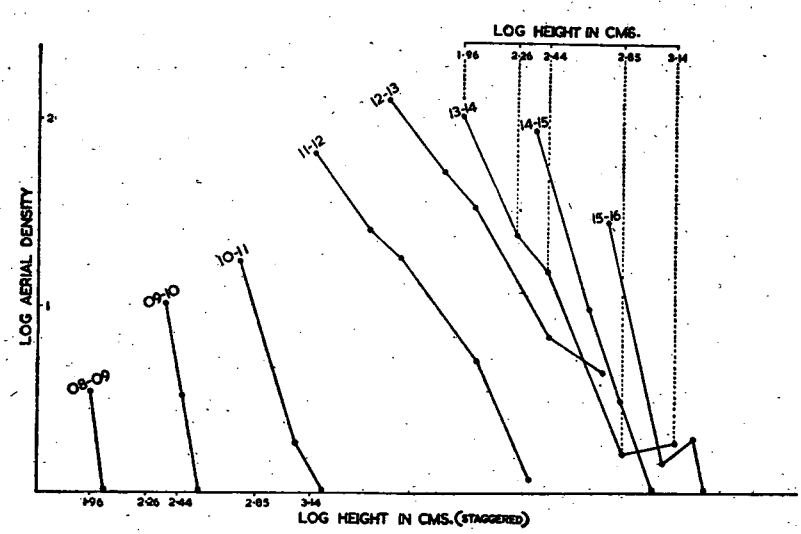

FIGURE 2—*The density on height profiles of Shot-hole borers, illustrating the daily changes in their aerial distribution. The numbers beside each graph denote the hour.*

1.6 Times of dispersal

Work on the phenology (patterns of distribution in relation to time and climatic changes) of the borer has indicated that there are two main periods of dispersal in the year. A distinct major peak of dispersal around April, which includes the months of late March, April, May and perhaps early June ; and a not so distinct minor period of dispersal around October-November. This trend in dispersal has been observed not only for *X. fornicatus*, but for all other Scolytidae (13 *Xyleborus* species and 7 species of other genera), caught in flight in the suction traps in a tea field. These studies on the phenology of Shot-hole Borer populations continue.

2 Studies on recolonization and reinfestation

The mode of recolonization and reinfestation of a tea field sprayed with Dieldrin is being investigated. Both the aerial populations as well as the populations in the crops, of a sprayed and an adjoining unsprayed tea field, and their progressive build up, are being recorded. Monthly "line-sampling" in the crop (whereby 25 standard units from each contiguous group of 5×5 tea bushes are collected in transections, or lines of sampling, from the borders of the sprayed and unsprayed fields into their centres) is designed to investigate "edge-effect" in infestation (progressive infestation of the sprayed field, from the edges bordering the unsprayed tea field) (Calnaido 1964).

The evidence from data collected to-date does not indicate appreciable or marked "edge-effect" in infestation. This evidence, in concurrence with the new knowledge about the flight and dispersal of Shot-hole Borer, indicate that generally, reinfestations are primarily caused by the deposition of borers from wide-spread aerial dispersion.

3 The build-up of borer populations in a tea field

Investigations are in progress on the abundance and distribution of Shot-hole Borer in relation to pruning date and the growth of the tea throughout the pruning cycle. Comparative studies of the borer populations in the crop, in galleries in tea stems, and the aerial populations above the crop are designed to evaluate the factors that control the build-up of these populations in tea fields.

The growth of the populations in the crop is measured, monthly, by two methods, the standard unit method (Judenko 1958) and by collecting random samples of whole branches of tea stems too. The aerial population above the crop is measured, daily, by a vertical series of suction traps, at heights of 3′ (crop level), 6′, 9′, and 45′ (Calnaido 1964). The full analysis of the data will only be possible when the tea field has completed the entire length of the pruning cycle, which will be in May, 1965.

4 Studies on life history

Tea plants in the field are artificially infested with beetles, caught in flight in the suction traps and also removed from galleries in tea stems, to study their life history. Dissections of the galleries in tea stems are made at periodic intervals and the relevant observations are recorded. These experiments seek particularly to obtain information on behaviour patterns, the presence or absence of parthenogenesis, teneral period, brood formation, and longevity of adult life in the field. Over 200 infestations were made and about half this number dissected. This work will be concluded about June, 1965.

5 Comparison of sampling methods

An efficient, economical and convenient sampling method is essential in any study of insect ecology. Therefore, an experiment was designed to evaluate the effectiveness of various sampling methods. Water traps of different colours, white, green and yellow (Calnaido 1962), sticky traps (Ibbotson 1958), and window traps (Chapman & Kinghorn 1955) were compared with the standardised 18″ suction trap (Johnson & Taylor 1955).

Suction traps were most suitable for sampling aerial borer populations. The Chapman's window traps are much less effective, but may be conveniently used in a large scale sampling program. The water traps of all colours and the sticky traps were definitely inadequate for sampling aerial borer populations.

The effectiveness of the standard unit method for assessing borer populations in the tea bush is under investigation, by comparing this method with the sampling of entire branches of tea, collected at random.

Research on other Insects

6 Family Scolytidae

Records of a two-year period of sampling by daily catches in suction traps enabled a study of the relative abundance and distribution of Scolytid beetles in a tea field. Of over 22 thousand beetles of all genera collected 90% were of the genus *Xyleborus* and of about 20 thousand beetles of the genus *Xyleborus* approximately 32% belonged to the species *X. fornicatus*.

This two-year record of sampling also revealed the distribution, in the year, of two periods of abundance and aerial dispersal of 20 species of Scolytidae, caught in suction traps (refer section 1.6 of this report).

7 Identification and collection

Beetles collected in suction traps are being sent to Professor K. E. Schedl, in Austria, for identification and the named species received build up our collection, which to-date includes 35 species of Scolytidae, of which 17 are *Xyleborus* species. More specimens continue to be sent for identification.

8 Tea Tortrix and Macrocentrus parasite

Studies on the relative abundance and distribution of the Tea Tortrix moth and the *Macrocentrus* parasite reveal that there are seven generations each, in the year, of these two insects, at Hantane (2,500 ft).

The generations of both insects run almost parallel ; with the peak numbers of each generation of the *Macrocentrus* parasite just proceeding that of the Tortrix moth. As expected, this indicates the very close relationship of this pest—parasite complex. The two-year record (1963 & 1964) of sampling also shows that *Macrocentrus* populations built up to peak numbers around mid-year and then gradually dropped to very low numbers in December.

At Hantane (2,500 ft), the mean life cycle of the Tea Tortrix moth is 51 days, while that of the *Macrocentrus* parasite works out to 46 days. At St Coombs at 4,500 ft, King (1937) and Gadd (1946) estimated the mean life cycle of the Tortrix moth to be 70 days and that of the *Macrocentrus* parasite as 50 days, respectively. The life cycles of shorter duration at Hantane can be attributed to the higher temperatures at that elevation.

It is hoped that the comparative studies of these two insects, the Tea Tortrix moth and the *Macrocentrus* parasite, and that of Shot-hole Borer, wilc help to ascertain whether it would be possible to regulate the chemical contro of Shot-hole Borer in order to achieve maximum benefit from the natural or biological control.

9 Diurnal flight Periodicity of insect pests of tea

The hourly catches in the suction traps have enabled us to study the daily flight rhythms of all insects in a tea field. This work, apart from its academic interest, will be useful as a guide to the interpretation of samples.

The diurnal flight periodicities of Shot-hole Borer, Tea Tortrix moth and *Macrocentrus* parasite are known and similar work on other insect pests of tea is in progress.

10 Lectures and Symposia

Dr D. Calnaido read two papers, one on "Studies on the Population Ecology of Shot-hole Borer" at the 13th Conference of the Tea Research Institute (January 1964), and another on "The flight behaviour of Shot-hole Borer of tea and its bearing on the distribution of the pest in Ceylon", at the 20th Annual Sessions of the Ceylon Association for the Advancement of Science (September, 1964).

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REPORT OF THE BIOCHEMIST FOR 1964

G. W. Sanderson, BSc, PhD

Staff

Mr T. S. Nathan, Senior Technical Assistant, died in April and it is with deep regret that this loss is recorded. Mr R. R. Selvendran, Research Assistant, left Ceylon in September to begin postgraduate studies at the Low Temperature Research Station, Cambridge, England, under the supervision of Dr F. A. Isherwood. Mr B. P. M. Perera was promoted to the grade of Senior Technical Assistant in November. The Biochemist acted as Advisor for Research to the Technology Division during the period January through October in the absence of a Technologist. The Biochemist left Ceylon on 15 December on three months' home leave.

Research Facilities

A major portion of the scientific equipment and supplies needed for our research programme arrived during the year and it has already been put into use. Of particular importance was the installation of a constant temperature cold room which was completed in July. A Controlled Environment Plant Growth Chamber arrived in December and a new Chromatography Room is nearing completion.

Experimental

1 The Biochemical Basis of Quality in Tea

Continuing an investigation begun in 1963 (Sanderson 1964a, 1964b), clones TRI 740 (a low quality clone) and TRI 777 (a high quality clone) were sampled regularly during the dry or flavoury season. Samples of fresh flush were analysed for eleven chemical quantities and the bulk of the flush was made into black tea for evaluation by a panel of professional Colombo tea tasters. The results were analysed and a comparison was made of the chemical composition of flush in the dry season and in the wet season. The results of this investigation to the end of the year have been published (Sanderson & Kanapathipillai 1964) and they are summarized in Table 1.

TABLE 1—*Summary of Differences found in the Chemical Composition of Fresh Flush from Clones TRI 740 and TRI 777*

(0, no difference ; + or —, increase or decrease significant at 5% level ; + + or − −, increase or decrease significant at 1% level)

Chemical constituent	Significant differences Between clones*		
	In wet season†	In dry season††	Between seasons**
Moisture content	0	+	0
Total nitrogen	+ +	+ +	0
Caffeine	+ +	+ +	0
Protein	+ +	+ +	0
Total flavanols	+ +	+ +	0
Crude fats	−	− −	0
Ash	− −	− −	+ −
Pectin	0	−	+
Total soluble solids	+ +	0	+
Crude fibre	0	0	−
Polyphenol oxidase activity	+ +	+ +	− −

*Clone TRI 777 was compared to clone TRI 740.
**The dry season was compared to the wet season.
†The wet season was taken to be the period 27 March to 2 December 1963.
††The dry season was taken to be the period 31 January to 30 April 1964.

The investigation has been extended in a limited way to include eleven clones (Sanderson, 1964b) but before any generalisations can be made it will be necessary to thoroughly investigate a large number of clones of known quality potential.

2 The Seasonal Variation in the Chemical Composition of Tea Shoot Tips (Flush)

All of our work to date has shown that there are appreciable seasonal variations in the chemical composition of tea flush (Sanderson 1964b ; Sanderson & Kanapathipillai 1964 ; Sanderson & Perera 1965 ; Sanderson & Selvendran 1965). Workers in North-east India (Wood *et al* 1964a, 1964b) have recently published data which also show this. However, the actual effect of any one of the elements which make up climate is virtually unknown at present.

The element of climate to which we have given some study in 1964 is rain. Recently, Tukey and his co-workers have been studying the leaching effect of rainwater on plants in considerable detail (Tukey & Tukey 1959 ; Tukey & Morgan 1964 ; Mecklenburg & Tukey 1964 ; Morgan & Tukey 1964). These workers have found that virtually all of the soluble chemical constituents in plant leaves are leached to some extent by rain. It has been suggested that this may be an important factor in tropical agriculture where high levels of rainfall are the rule (Tukey & Morgan 1964).

We have now begun an investigation to determine the importance of leaching by rain in the culture of tea in Ceylon. In our initial experiments we placed polythene sheets under tea plants in such a way that rainwater which passed through the foliage would be caught and collected. This water was then analysed for several chemical quantities which are found in tea leaves. Some typical results are shown in Table 2 and a chromatogram of the polyphenols found is shown in Figure 1. These results clearly indicate that rain does leach soluble substances from tea leaves. Additional research to determine the importance of these results is in progress.

TABLE 2—*Chemical Analysis of Rainwater which has or which has not passed through Tea Bushes*

Description of sample	Total soluble solids	Ash	Total flavanols*	Amino acids**
		(µg/ml rainwater)		
1 Rainwater which has not passed through tea bushes (direct from sky)	0	0	0	0
2 Rainwater which has passed through a tea bush ; Sample 1	201	176	0.32	0.086
3 Rainwater which has passed through a tea bush ; Sample 2	95	88	0.16	0.042

*By vanillin test : as catechin.

**By ninhydrin test : as alanine.

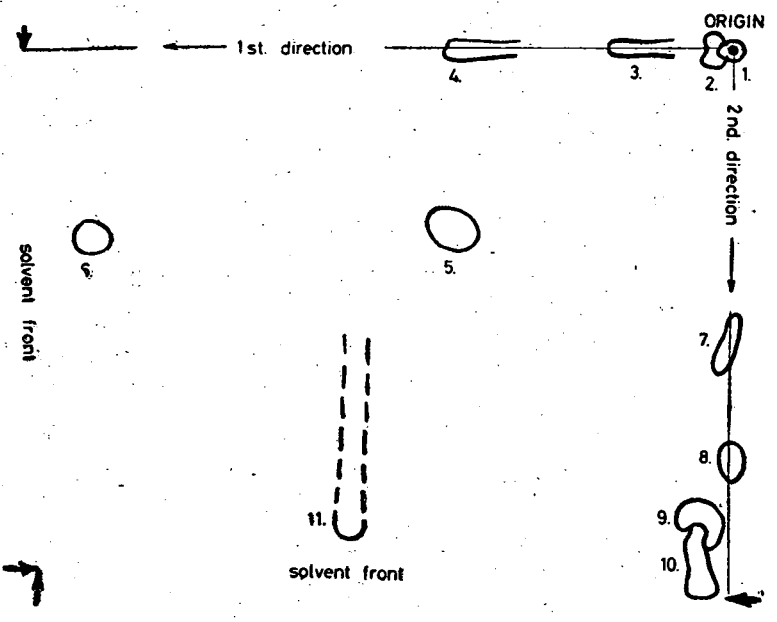

Figure 1—Chromatogram of rainwater which has passed through the foliage of tea bushes showing some of the leaf substances which are leached out by rainwater. Spots were located by their flourescence under ultraviolet light indicating that these substances are aromatic polyphenols. The chromatogram was developed in the 1st direction with butanol: acetic acid: water (4:1:2.2) and in the 2nd direction with 2% acetic acid.

Detailed studies of other factors contributing to climate are planned for 1965 when the new Controlled Environment Plant Growth Chamber becomes operational.

3 The Chemistry of Withering in Tea Manufacture

Results from several independent investigations carried out in our laboratory (Roberts & Sanderson 1965 ; Sanderson 1964c, 1965d ; Sanderson & Perera 1965 ; Sanderson & Selvendran 1965) and elsewhere (Bhatia 1961, 1962 1963 ; Roberts & Wood 1951 ; Trinick & Choudhury 1963 ; Wood & Chanda, 1955, 1956) made it apparent that the chemical changes occuring in plucked tea shoot tips (flush) during withering in tea manufacture were numerous and appreciable ; the chemical changes now known to take place are summarized in Table 3.

Consideration of the information shown in Table 3 and the experience of planters led to the formulation of a "Theory of Withering in Tea Manufacture". The Theory has been stated in the form of three principles as follows :

Principle 1. Storage of flush for a period of time is necessary to allow chemical changes to take place whether a wither is desired or not if we wish to make a product with good traditional characteristics.

Principle 2. Physical withering is necessary for good fermentation if we wish to use orthodox rolling. Leaf processing methods which cause a very high percentage of the cells in the flush to be broken can substitute for physical withering but at the expense of destroying the traditionally accepted appearance of the made tea.

TABLE 3

Summary of Changes now known to occur in Tea Flush during Withering

Description of change	Importance of change in tea manufacture	Dependance of change on moisture loss	References
1. Loss of moisture	Very important in orthodox manufacturing. Absolute importance is still unknown	—	Sanderson, 1964c
2. Increase in free amino acids	Probably important for colour and quality	Independent	E. A. H. Roberts & Wood 1951; G. R. Roberts & Sanderson, 1965
3. Increase in caffeine	Probably increase value of tea	Independent	Wood & Chanda, 1955, 1956; Sanderson, 1964c
4. Increase in soluble carbohydrates	Unknown	Partially dependent	Sanderson & Perera, 1965
5. Changes in level of organic acids	Unknown	Independent	Sanderson & Selvendran, 1965
6. Changes in activity of polyphenol oxidase	Probably important with slow fermenting clones or slow fermenting fields of tea	Independent	Sanderson, 1964d.
7. Increase in soluble phosphorus	Unknown. Probably related to points 4 and 5 above	Unknown	Bhatia, 1964
8. Changes in permeability of cell membranes	Probably important in obtaining even fermentation	Dependent	Sanderson, 1964c

Principle 3. The length and temperature of the withering period will affect the character of the made tea. Low temperatures (about 50°F to 60°F) and short withering periods (about 12 hours) favour the development of quality and flavour while high temperatures (80°F to 95°F) and longer withering periods (20 to 30 hours) favour the development of colour at the expense of diminishing quality and flavour.

For a full discussion of the theory, the reader is referred to a recent publication in the Tea Quarterly (Sanderson 1964c).

It is hoped that the above formulation will lead to a fuller understanding of the principles underlying this time-honoured process which in turn will allow for systematic progress in methods of tea manufacture.

4 Nitrogen Metabolism in Tea

The characterization of an enzyme system capable of breaking down proteins to free amino acids (tea leaf peptidase) was completed. A full report of this investigation has been published (Sanderson & Roberts 1964) and a summary of the properties of this enzyme system is shown in Table 4. This enzyme system is believed to be responsible for the increase in free amino acids during withering (Table 3) but other factors may also be important in this connection (see Section 5 below).

The changes which individual amino acids undergo during tea manufacture are now under study. In summary, we find that all amino acids increase during withering except theanine which does not appear to undergo appreciable changes during tea manufacture. Alanine, glutamine, and glutamic acid are noteworthy because they show the greatest increase. During fermentation there is a decrease in the level of free amino acids which is probably of importance in determining the character of the made tea (Wickremasinghe 1965). A full report of our findings to date with an exposition of their probable importance in tea production is in preparation (Roberts & Sanderson 1965).

TABLE 4—*Properties of the Peptidase Enzyme System in Tea Shoot Tips*

(*from Sanderson and Roberts 1964*)

	Property	Value for peptidase system
1	Optimum pH	5.0
2	Optimum temperature (in 1 hr assays)	52°C (125°F)
3	Part of flush with greatest specific activity	Bud > 2nd Leaf > 1st Leaf > Stem
4	Part of flush with greatest amount of activity	2nd Leaf > 1st Leaf > Bud > Stem

5 Organic Acid Metabolism in Tea

A study of the non-volatile organic acids in tea plants which are separable on silica gel has been concluded. A histogram depicting a typical chromatogram of these acids is shown in Figure 2. The levels of the major organic acids which were studied is shown in Table 5. A full report of this investigation has been prepared for publication (Sanderson & Selvendran 1965).

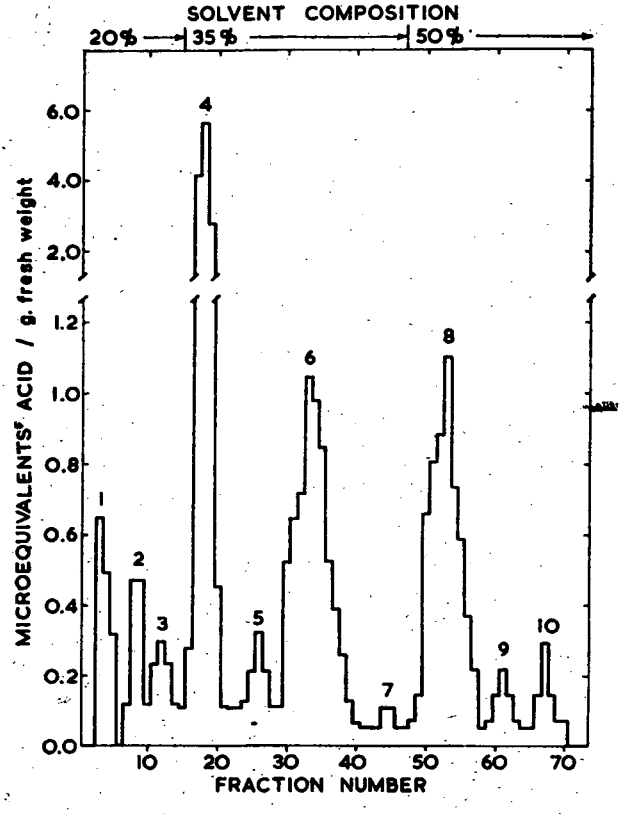

Figure 2 — Histogram showing separation of organic acids in an extract of tea shoot tips. Peaks correspond to the following acids : 1-Unknown 1, 2-Succinic, 3-Unknown 2,4-Oxalic, 5-Unknown 3, 6-Malic, 7-Unknown 4, 8-Citric, 9-Unknown 5, and 10-iso Citric. (From Sanderson & Selvendran, 1965)

TABLE 5—*The Level of Organic Acids in Tea Shoot Tips*

Acid	Amount of acid*	
	µeq/g fr wt	mg/100g fr wt
Unknown 1	1.11±0.46	—
Succinic	1.17±0.81	6.9± 4.8
Oxalic	21.58±5.56	97.1±25.1
Malic	5.33±1.44	35.7± 9.6
Citric	4.09±2.68	26.2± 17.2
Unknown 5	0.44±0.31	—
iso-Citric	0.86±0.77	5.5±4.9

*Acid values are based on determinations made on clone TRI 2024 between 20-12-63 & 27-7-64 The mean values and standard deviations are given.

The acids studied were found to represent only about one-fourth of the total acidity in tea shoot tips ; the remainder of the acidity is probably made up of pectic acid (Ramaswamy 1960) and much smaller amounts of inorganic and volatile acids.

Studies with radioactive tracers produced evidence that organic acids are converted directly to amino acids during withering in tea manufacture (Selvendran & Sanderson unpublished results). The data indicated that appreciable amounts of malic acid and citric plus iso-citric acids were metabolized to aspartic acid and glutamic acid respectively, during withering. The relative importance of these changes and the changes brought about by the action of peptidase on protein remains to be determined.

6 Carbohydrates in the Tea Plant

A study of the carbohydrates in tea plants has been initiated. These substances are of considerable importance in plants in general because of their central role in cell metabolism, in forming the structural material of cells, and in biogenesis of many other cell constituents. Our initial results with respect to the carbohydrates present in tea shoot tips are given in an article to be published in the Tea Quarterly (Sanderson & Perera 1965).

7 Polyphenol Oxidase in Tea Shoot Tips

As mentioned above (Table 3), the level of polyphenol oxidase was found to fluctuate during withering in tea manufacture (Sanderson 1964d). The fluctuations were found to be dependent on time and temperature but independent of withering itself. These findings were incorporated into a Theory of Withering (Sanderson 1964c).

In order to determine the cause of this phenomenon, and to solve other problems (Bendall 1960 ; Bendall & Gregory 1961), it is desireable to obtain the enzyme in a more or less purified state. In the course of this work it was discovered that the enzyme is, in fact, a soluble enzyme contrary to previous reports (Roberts 1962 ; Stahl 1962). This most interesting discovery opens the door to a reinvestigation of the properties of this enzyme.

Preliminary reports of this work have been made (Sanderson 1964e, 1965a).

8 Peroxidase Activity in Tea

A study of the enzyme peroxidase in tea plants was initiated : The object of the investigation is to determine the importance of this enzyme in tea culture and to study the factors affecting its activity. The investigation is only in its initial stages and further comments will be reserved until more results are available.

9 Caffeine Content of Tea Fluff

A brief survey of the caffeine content of tea fluff was made in response to a request from a commercial source. The results of this survey are shown in Table 6.

TABLE 6—*Caffeine content of fifteen samples of Tea Fluff and Related Tea waste materials*

Description of Sample	Factory	Elev. (ft)	Date of Sampling	Caffeine (% dry wt)
Tea fluff	Olympus	100—200	15/8	2.12
Tea fluff	Yahaladuwa	200	12/6	2.62
Tea fluff	Boscombe	1700	15/8	2.25
Tea fluff	Glenalmond	1800	6/8	2.39
Tea fluff + drier blowout	Ury	1800—4800	6/6	3.21
Tea fluff + sweepings	Raxawa	2750	15/6	2.26
Tea fluff	Raxawa	2750	15/6	2.12
Drier blow out	Lonach	2850	6/6	2.45
Tea fluff	Lonach	2850	6/6	2.17
Tea fluff + fibre	Ellamulla	3200—5500	4/4	2.20
Tea fluff	Laxapana	3780—5600	6/8	2.19
Tea fluff	Chrystler's Farm	4000	15/8	2.22
Tae fluff + waste tea	Forres	4200	6/8	2.17
Tea fluff + fibre + waste tea	Wanarajah	4360	6/8	3.14
Tea fluff	St Coombs	4500	10/6	1.92
		Average ± Standard Error		2.36 ± 0.37

10 Tea tasting Panel

A tea tasting panel at the Tea Research Institute, Talawakele, composed of Institute staff members was organized. The purpose of the panel was to evaluate experimental teas by modern methods of sensory analysis. Training included tasting of selected teas once a week, visits and a seminar by an international expert (Dr Gisela Jellinek). The panel trained for about 25 weeks after which some degree of competence was achieved by eleven panel members. However, the project was discontinued before the objective had been achieved because of the lack of a competent instructor near at hand. It is hoped that this project can be carried on under the supervision of the Tea Taster once he is appointed.

Acknowledgements

Assistance with the training of the Tea Tasting Panel given by Messrs George Steuart & Co Ltd through Mr J. F. A. P. Peries is gratefully acknowledged.

It is a pleasure to acknowledge the assistance given to the Tea Tasting Panel by Dr Gisela Jellinek, Heidelberg, Germany, in the form of a seminar on "Modern Methods of Sensory Analysis".

The assistance of Dr P. P. G. L. Siriwardena in providing the facilities of the Radiochemical Centre, University of Ceylon, for our use is gratefully acknowledged.

The following gifts of investigational materials are acknowledged with thanks:

(*a*) 500 g Polycaprolaktam Powder from Messrs Farbwerke Hoechstag Werk Bobingen, Germany.

(*b*) 20 yd Melinex Film, guage 25, and 20 yd Melinex Film, guage 200, from Messrs Ceylon Chemical Industries, Ltd., Colombo.

(*c*) 8 oz Polyclar AT from Messrs General Aniline and Film Corp, New York, New York, U.S.A.

The Technology Division staff have rendered an invaluable service in making experimental teas and in having these teas evaluated.

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REPORT OF THE BIOCHEMIST (MANUFACTURE) FOR 1964

R. L. Wickremasinghe, BSc, PhD, FRIC

Staff

I assumed duties on 23rd June 1964, and Messrs K. P. C. W. Perera and M. T. Subramaniam took up their appointments as Technical Assistants on 1st September and 15th October respectively. Dr A. S. L. Tirimanna was selected as Research Officer and will join the Division in January, 1965.

Experimental

Keto-acids of tea—Methods for the identification of the keto-acids in tea were evolved, and a study is being made to find out whether these compounds have any relation to the aroma complex of tea. Two clones, TRI 777 and DT I, have been examined so far and found to show qualitative and quantitative differences in the pattern of keto-acids appearing during manufacture (Table 1).

TABLE 1—*Keto-acids in clones TRI 777 and DT 1*

Keto acid	Flush		Withered		Partly Fermented		Fully Fermented	
	777	DT 1	777	DT I	777	DT1	777	DT 1
Oxaloacetic	+	+	—	+	—	—	—	—
α —ketoglutaric	5+	10+	5+	10+	3+	5+	3+	+
α —keto-adipic	—	+	—	+	—	+	—	—
Hydroxypyruvic	+	+	—	+	—	—	—	—
Glyoxylic	+	+	—	+	—	—	—	—
Pyruvic	+	+	+	+	+	+	+	+
p—hydroxy-phenylpyruvic	—	+	—	+	—	—	—	—
α —keto isovaleric	—	+	—	+	—	—	—	—
α —keto isocaproic	—	+	2+	10+	+	3+	+	—

(Figures are an approximate indication of the quantities present).

The most interesting observation was the increase of α keto-isocaproic acid in withered leaf, followed by its decrease during fermentation, since this keto-acid has been implicated in the biogenesis of terpenes and carotenoids.

A study of the enzyme systems responsible for the formation of keto-acids has been initiated and the presence of an oxidative deaminase for the amino—acid, L—leucine, has been detected.

Carotenoids of tea—Methods for the extraction, separation and identification of the carotenoid compounds of tea have been examined. Thin-layer chromatographic methods showed the presence of at least three carotenoid compounds, one of which has been identified as β—carotene. Preliminary experiments indicated that carotenoids increase during fermentation.

Polyphenols of tea—Quantitative determinations of the different groupings of polyphenols, m—dihydroxy, o—dihydroxy and leucoanthocyanins, in eight different clones have been made and the compounds identified by paper chromatography. The changes during manufacture in these groupings and in the ratio of oxidised to unoxidised polyphenols has been followed in three clones.

Tissue culture of tea callus—Attempts to grow tea callus in an artificial medium have been unsuccessful so far.

Publications and Communications

WICKREMASINGHE, R. L. and SWAIN, T. (1964) The Flavour of Black Tea. *Chem. and Ind.* 1574-1575.

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REPORT OF THE ACTING TECHNOLOGIST FOR 1964

D. Kirtisinghe, BSc, PhD, DIC

1 Staff

Mr E. L. Keegel, former Technologist left the services of the Institute on 31st December 1963. Mr L. S. Weragoda was then appointed Officer-in-charge of the Technology Division with Dr G. W. Sanderson overlooking the research activities, till Dr D. Kirtisinghe assumed duties as acting Technologist on the 16th October, 1964 after successfully completing four years post-graduate training at the Imperial College of Science and Technology, London.

Mr W. Joseph has been appointed Research Assistant and is due to join the staff of this division on 1st January 1965. Mr S. Samarasingham was transferred to Technology from Agricultural Chemistry as Technical Assistant on 21st September.

2 General

Correspondence and advisory work continued to be heavy. 434 letters of an advisory nature were despatched and in the course of this work it was very encouraging to note that a large number of estates have shown a great deal of interest during the past year in increasing withering capacities to cope with the increased crops of recent years. This increase in capacity is mainly due to the replacement of hessian tats by tats of synthetic material, which permit an equivalent wither to be taken at a higher thickness of spread (Weragoda 1964), together with a simultaneous increase in the throughput of air by the withering fans. The introduction of Trough Withering systems has also helped to relieve congestion.

3 Clonal Manufacture

128 clonal manufactures were made by the mincing machine technique (Keegel 1953) and on the miniature scale (Keegel 1954). The classification, according to quality of some of the more interesting of the clones tested in 1964, is as follows :

Classification Group	Estate	Clones
A 1/2	Downside	73 and 317
	Yuillefield	YF 6/1
	Concordia*	CC 34, CC72, CC/CL30 CC/CL35, CC/CL 64, HS10a, PW14, UR1.
A 2	Downside	BR 1
	Goatfell	GF 5/01
	Park*	PK 2
	Poysland*	SM 404
B	Concordia*	SI 76
	Downside	304
	Goatfell	SM 401

*Denotes provisional classification—needs further testing.
A 1/2 Potentially good quality, but more evidence is required for classification in Group 1.

A 2 Above average quality and capable of producing a very good tea under favourable weather conditions.
B Average quality but could have very good quality, at certain times.

The institute has the equipment and is eager to give all possible assistance to estates which do not possess facilities for miniature manufacture, but wish to have their clones tested for quality. This service is being extended to St Joachim, Ratnapura, and shortly the Institute is to have miniature manufacturing equipment at the Kottawa, Passara and Hantane sub stations. It is hoped that a large number of estates would make use of this offer to have their clones tested.

Leaf taken for test manufacture should come from bushes which have been in regular plucking for at least six months. We can manufacture leaf from a single bush on the mincing machine scale but a more reliable guide is obtained by a manufacture in the miniature rollers for which we shall require 5 lb of green leaf from each clone.

4 Rotorvane manufacture

Experiments on rotorvane manufacture were continued with an 8″ machine. Progress was retarded to some extent during the period August-October, when the experimental machinery could not be used on account of the factory electrification programme.

During the year under review three trials on rotorvane manufacture were carried out. The first two of these trials were conducted with a 1962 model rotorvane and the third on the 1963 model.

The modifications on the latter model consisted of :

(*a*) An arrangement whereby reverse pitch vanes could be introduced at will, instead of being confined to the use of all forward vanes as on the 1962 model.

(*b*) An Iris end-plate, in place of a saucer-shaped pressure plate. Increase in the aperture of the Iris end-plate reduced the pressure on the leaf during rolling and *vice-versa*.

4.1 Period of Fermentation

Five periods of fermentation ranging from 1 to 3 hours at half hourly intervals, and having a fermentation range of one hour each for pure rotorvane teas, were compared with a tea rolled in a conventional roller with a 2¼ hour period of fermentation and the same fermentation range of 1 hour.

The evaluation of these results was done by two panels of tasters one in London and the other in Colombo. The investigation revealed that the normal periods of fermentation given to orthodox teas were equally suited to Rotorvane teas. The 100% rotorvaned tea with a 2 hour period of fermentation showed no significant difference from that of the orthodox tea with respect to infusion, colour, strength, quality and valuation. Longer fermentation periods of 2½ and 3 hours improved the colour and strength of rotorvaned teas at the expense of quality and flavour, while shorter periods gave teas with poorer colour and strength with no improvement in the other characteristics.

This trial which was carried out during the Dimbulla flavoury season also revealed that Rotorvaning had no adverse effect on flavour.

4.2 Mixed Rotorvane—orthodox rolling programmes

A large number of well organised combinations of rotorvane-orthodox programmes are possible; Four of these mixed rotorvane-orthodox rolling programmes were investigated after it was established that the dhools, whether rotorvaned or orthodox, ferment more or less at the same rate.

The first of these four programmes gave very encouraging results while the others produced teas which were held by the tasters to be equal to the teas manufactured in conventional rollers with a rolling programme of four thirty -minute rolls and an 8 on 2 off method of pressure application.

In programme No 1 the withered leaf was preconditioned in an orthodox roller for ten minutes under very light pressure, and then passed directly into an 8" rotorvane running at 25 rpm. It was then passed into a rotorvane aerator and 45-60% dhool extracted on roll breaking with a combination of 5 and 6 mesh. The bulk was then given two thirty-minute rolls in a conventional roller to reduce the big bulk to 10%. Details of these experiments and results have been published (de Silva and Sanderson 1964).

4.3 Speed, pressure and reverse pitched vane

During the latter part of 1964 rotorvane experiments were conducted on a machine incorporating the 1963 modifications.

Twelve different treatment combinations were investigated in this trial which is designed to reveal the effect of the following factors and their interactions :

(*a*) Three speeds 16, 25 and 36 rpm.
(*b*) Two pressures maximum and minimum, and
(*c*) One reverse pitch vane at centre *vs* all forward vanes.

This experiment will be concluded early in 1965 and it is hoped shortly to publish these results in the Tea Quarterly.

5 Trough Withering

A comparison is being made of teas from trough withered leaf with that of leaf withered on conventional tats with equal periods of withering. The same outturn of 45% made tea to withered leaf is aimed at for both methods.

Indications are that teas withered in the trough with an inlet temperature of 80°F and a hygrometric difference of 10-12°F are not significantly different in respect of valuation from teas withered on tats at 72°F and 5°F hygrometic difference, despite differences in temperature and duration for which hot air has been passed.

6 Fermenting Surfaces

An investigation is being carried out to test the suitability of nylon mesh, which is now quite popular as a fermenting surface, in comparison with PVC sheets and concrete tables as a surface on which to ferment dhools. A 2½" and 3½" thickness of spread is being tried out with each material.

Results are still coming in, but indications are that the tea appears to ferment equally well on each of these surfaces.

7 Acknowledgements

We have continued to receive considerable assistance from the tea tasters in Colombo and to all these gentlemen who have spared so much of their time to taste our experimental teas, we express our grateful thanks.

Publications

De Silva, W. C. A. & Sanderson, G. W. (1964) Rotorvane manufacture techniques *Tea Quart.* **35** : 230-234.

Weragoda, L. S. (1964) Developments in Rotorvane Manufacture. *Tea Quart.* **35** : 96-100.

Weragoda, L. S. (1964) Withering on materials of synthetic fibre. *Tea Quart.* **35** : 171-173.

References

De Silva, W. C. A. & Sanderson, G. W. (1964) Rotorvane manufacture techniques *Tea Quart.* **35** : 230-234.

Keegel, E. L. (1953) Vegetative propogation of tea—The manufacture aspect. *Tea Quart.* **24** : 82-89.

Keegel, E. L. (1954) A note on the operation of the miniature roller. *Tea Quart.* **25** : 60-67.

Weragoda, L. S. (1964) Withering on materials of synthetic fibre. *Tea Quart.* **35** : 171-173.

REPORT OF THE STATISTICIAN

P. Kanapathipillai, BSc, FSS

Staff

There were no changes in staff. The functions of the division were, therefore, confined mainly to the design and analyses of field experiments.

Designs

1 Incomplete Block and Youden Square designs were used to test the consistency of each of the members of a Tea-tasting panel.

2 Designs were also drawn up to test a single tea taster's ability to distinguish different strengths of tea (Kendall T) and the degree of concordance between tasters as a team (Kendall's W).

3 Fractional Replication. A one-third replicate of a 3^5 design (three levels of each of N, P, K, Ca, Mg) was arranged in 9 blocks of 9 plots each in such a way that all main effects and first order interactions were free from confounding.

Analyses—Multiple Regression

1 These data on Shot-hole borer were collected in suction traps.

The independent variables were log take-off numbers, maximum temperature (°F), sunshine hours and mean wind speed (mph). These variables were analysed to study their relationship to numbers of Shot-hole Borer in flight.

2 These data were from random samples of wood 4 inches long taken from fields six to eight months after pruning.

The dependent variables were :

(*a*) *Log* I_n—the log number of galleries at any given sampling time.

(*b*) *Available wood*—being defined as $\frac{100-G\%}{100}$ where G% refers to the percentage of sample units with galleries.

(*c*) *Rainfall in the same two months.*

(*d*) *Rainfall in the preceding two months.*

(*e*) *Rainfall in the two months preceding* (*d*).

The independent variable was log I_n+1, viz. the log number of galleries two months later, *ie* at the next sampling time.

These data were analysed in respect of experiments in each of the following estates Pinnawella, Demodera, Delta, Medecombra and Queenstown.

The Division also analysed data from over fifty experiments many of them involving covariance and heavy computational labour in various transformations.

General

A course in elementary statistics for officers in the Intermediate and Junior Technical Grades was given.

The Division continued to give advice on sampling and other statistical problems.

ANNUAL REPORT OF THE CHIEF ADVISORY OFFICER FOR 1964

C. B. Foster-Barham, MA

1 Correspondence and Visits

During the course of the year, total correspondence involved some 2293 letters, of which 1827 were written from St Coombs, 454 from the T R I sub-station at Passara, and the remainder from St Joachim Estate Ratnapura, where a District Advisory Officer has now been stationed since 10th December. The total number of estates, which made use of the Advisory Division services during the year, was 482, representing a proportion of about 53% of estates on the Institutes' files. Included in these figures are 419 enquiries which came from non-estate sources.

A total of 236 visits to estates were made during the year, inclusive of 41 visits for field experimental purposes.

Other divisions of the Institute have dealt with special correspondence and have made estate visits in connection with their own particular lines of research which are not included in this report.

2 Staff

2.1 Mr J. V. Sabanayagam was appointed District Advisory Officer (Low-Country), stationed at St Joachim Estate, Ratnapura, with effect from 10th December. With the filling of this post by a whole-time Advisory Officer it has now become possible to satisfy a need, felt for some time, for estates in the Low Country to be able to be visited and kept in touch with, considerably more frequently than formerly possible by Officers who had also at the same time to undertake charge and duties attached to the sub-stations.

The Districts covered by Mr Sabanayagam in the Low Country have remained unaltered from those covered previously, namely those of Ratnapura, Rakwana, Morawak Korale, Galle, Kalutara, Matara and Weligama, Dumbara, Balangoda and parts of Kelani Valley in regards to those estates which are closer of access via Avisawella than they are from St Coombs, *ie* south of a boundary comprising the main road from Colombo, via Avisawella, as far as Kitulgalla.

2.2 Mr D. N. R. Wijewardena was appointed Technical Assistant in the Advisory Division with effect from 1st June, and took up duties at the TRI sub-station, Passara, on 1st November.

2.3 Mr R. K. Nathaniel, Research Assistant, was transferred on temporary appointment to the TRI sub-station at St Joachim Estate, Ratnapura, on the 10th of October, and returned to St Coombs on the 10th of December.

3 Soil and Plant Specimens from Estates

3.1 Generally very few samples were examined for pH during the year compared to last year (538) the number being only 143 at St Coombs and 93 at Passara, owing to pH apparatus having been out of order and necessitating the transfer of this work to Colombo firms. As many routine examinations of soil samples require the inclusion of eelworm analysis at the same time as that for

pH, and the Institute has now discontinued for some years routine eelworm analysis of estate soil samples, nearly all soil samples are sent direct from estates to Colombo. A few estates have been noted to be still sending their soil samples to the Institute for eelworm analysis, and it may therefore not be out of place to draw attention again to the announcement that was made in the Tea Quarterly dated September 1960 (page 116).

3.2 Cases of all types of pest and disease and of other conditions found in plant specimens of various kinds, examined both in the laboratory and in the field, numbered in excess of 950. Amongst these there were 108 cases in which the actual cause or causes of unsatisfactory growth or of death, or the identification of the cause of particular symptoms, could not be precisely determined or were actually unknown, while a further 53 cases involved specimens which arrived at the laboratory in unsuitable condition for diagnosis. An advisory leaflet on the submission of specimens for diagnosis and report, giving detailed instructions, has been complied in the light of past experience, and is sent out to estates whenever such cases occur.

4 In the report on pests, diseases, etc, given below, those for the Uva Province are not included having been submitted separately by the District Advisory Officer in his report which subsequently follows. Cases below are given in respect of estates who submitted specimens for diagnosis and report, for those who were visited, and who made general enquiries.

5 Fungal Diseases

5.1 Poria hypolateritia (Red Root Disease)

Fewer cases of this disease were reported in 1964 than in 1963, the number being 34 as against 57. 26 estates in 15 districts were involved in reporting fresh cases, the highest number of cases (14) being reported in Dimbulla district The other districts, and number of reported fresh cases in each were :

Dickoya (5), Dickoya Lower (1), Dolosbage (1), Hewaheta Lower (3), Kelebokka (2), Kotmale (1), Maskeliya (2), Matale East (1), Maturata (1), Pussellawa (2), and Udapussellawa (1).

There were also 14 general enquiries from 13 estates in 8 districts, mostly in connection with fumigation control of the disease.

5.2 Rosellinia arcuata—(Black Root Disease)

21 cases of this disease were reported amongst 12 estates in 8 districts, the number of cases in each of these districts being as follows :

Dimbulla (6), Kotmalle (1), Maturata (2), Pundaluoya (1), Nuwara Eliya (4), Rambode (1), Udapussellawa (5), and Maskeliya (1).

5.3 Rosellinia bunoides—(Black Root Disease)

This particular species of Rosellinia, which is generally encountered but rarely in Ceylon tea, was reported in 3 cases from Upper Hewaheta, Maskeliya and Pussellawa districts.

5.4 Ustulina deusta—(or *zonata*) (Charcoal Rot Disease)

20 cases of this disease were reported amongst 19 estates in 13 districts. 5 of these were in Dimbulla. 2 in each district were reported from Kalutara, Kelani Valley and Maskeliya, and 1 each from Dickoya, Dolosbage, Galle,

Kotmale, Matale South, Nilambe, Nuwara Eliya, Pussellawa and Ratnapura districts. Two estates also made general enquiries.

5.5 Fomes noxius—(Brown Root Disease)

There were 11 cases of this disease reported amongst 11 estates in 6 districts, the number of cases in each district being as follows : Dimbulla (3), Hewaheta Lower (1), Kalutara (1), Kotmale (1), Matale South (1) and Udapussellawa (4).

5.6 Fomes lignosus—(White Root Disease)

3 cases only were reported, from Kelani Valley, Kalutara and Ratnapura districts.

5.7 Phomopsis sp—(Branch and Collar Canker)

8 cases were reported amongst 7 estates in 3 districts, namely Kalutara (1), Maturata (1) and Udapussellawa (6). Two estates also made general enquiries.

5.8 In addition to the above, there were also reported the following:

(*a*) 5 cases of *Rhizoctonia soloni* (Black Blight Disease), from Galle, Kalutara, Kelani Valley, Morawak Korale and Ratnapura districts.

(*b*) *Aglaospora arculcata* (Thorny Stem Blight). 5 cases from Dimbulla (1), Galle (1) and Udapussellawa (3) districts.

(*c*) *Sphaerostilbe repens* (Violet Root Rot). 7 cases from Dimbula (1), Galle (4), Ramboda (1) and Udapussellawa (1) districts.

(*d*) *Collectotrichum camelliae* (Brown Blight). 3 cases from Galle District.

(*e*) *Pestalozzia theae* (Grey Blight). 5 cases from Dickoya lower (1) Galle (3) and Kelebokke (1) districts.

(*f*) *Marasmius equicrinis* (Horse-hair Blight). 2 cases from Galle District.

(*g*) *Cephaleuros sp* (Red Rust). 6 cases from Dolosbage (1), Galle (1), Matale East (2), Rakwana (1) and Ratnapura (1) districts.

(*h*) *Meliola sp* (Sooty Mould). 4 cases from Maskeliya (2), Morawak Korale (1) and Pusselawa (1) districts.

5.9 Other pathological conditions which were reported during the year were (*a*) 6 cases of chlorosis of tea leaf caused by high light intensity conditions in Dickoya, Dickoya Lower, Dimbulla, Maturata and Maskeliya Districts. (*b*) 3 cases of Phloem Necrosis in Dimbulla, Maturata and Ramboda Districts. (*c*) 4 cases of Rim-Blight or Marginal Necrosis in Dickoya Lower, Dimbulla, Hewaheta lower and Kotmale Districts. (*d*) 1 case of Velvet Blight (*Septobasidium sp*) in Kalutara District. (*e*) 1 case of "Little-Leaf" condition in Dimbulla District.

6 Deficiencies in Nutrients

6.1 Zinc—28 cases of this deficiency were reported amongst 27 estates in 13 districts, which included the following. Balangoda(1), Dickoya(2), Dickoya Lower (3), Dimbula (5), Dolosbage (2), Galle (2), Hunasgiriya (1), Kotmale (2), Maskeliya (4), Matale East (3), Nilambe (1), Pussellawa (1), Ratnapura (1).

14 estates also made 17 general enquiries on this subject.

6.2 Magnesium—Deficiency of this nutrient was reported in 33 cases amongst 33 estates in the following districts. Balangoda (1), Dickoya (3), Dickoya Lower (3), Dimbula (5), Dolosbage (2), Galle (2), Maskeliya (3), Matale East (2), Nilambe (2), Ratnapura (3) and Udapussellawa (2).

21 estates also made 24 general enquiries.

6.3 Nitrogen—8 cases were recorded in the following districts. Dickoya (2), Udapussellawa (2); Dickoya Lower, Dimbulla, Kelani Valley and Pussellawa (2); Dickoya Lower, Dimbulla, Kelani Valley and Pussellawa 1 case each. There were 3 general enquiries.

6.4 Potash—5 cases were recorded in the following districts. Dimbulla (2); Dolosbage, Kotmale, and Maskeliya 1 case each. There were 2 general enquiries.

6.5 Boron—2 cases were recorded in Dimbulla and Dolosbage districts.

7 Excess uptake of Nutrient

7.1 Manganese—5 cases were recorded on 5 estates in the following districts. Dickoya (1), Dickoya Lower (1), Dimbulla (2) and Nilambe (2).

8 Pests

8.1 Tortrix—28 outbreaks were reported amongst 24 estates in 17 districts in instances where specimens were sent, and also on estates visited. The number of cases recorded for each district concerned were: Dickoya (2), Dickoya Lower (1), Dimbulla (3), Dolosbage (3), Galle (1), Hewaheta Lower (3), Hewaheta Upper (1), Hunasgiriya (1), Kelani Valley (2), Maskeliya (2), Matale South (1), Morawak Korale (1), Pussellawa (1), Rakwana (2), Ratnapura (1), Rangala (1) and Udapussellawa (2).

21 estates in 19 districts also made general enquiries, including a number from the following additional districts: Alagalla, Ambagamuwa, Kadugannawa, Kalutara, Kelebokke, Matara and Ramboda.

Although it is possible here to report only on cases notified by estates directly to the Advisory Division, the actual number of further cases which occurred must have been quite appreciably larger, being not directly notified. In the Pussellawa and Hewaheta districts, for example, it is known that particular concern was felt over Tortrix during the year, and also quite a number of outbreaks occurred in Dimbulla. There were more cases of outbreak following dieldrin spraying in Pussellawa district than in Dimbulla where this was much less of a frequent practice and in which a comparatively larger number of natural outbreaks without dieldrin spraying, than in Pussellawa district are known to have occurred.

8.2 Shot-hole Borer—30 cases amongst 27 estates in 17 districts were recorded amongst specimens sent to the laboratory, and during estate visits, the number of cases in each district being as follows: Alagalla (2), Dickoya (1) Dickoya Lower (2), Dimbulla (3), Dolosbage (2), Hantane (2), Hunasgiriya (1), Kelani Valley (2), Kelebokke (1), Kotmale (1), Maskeliya (3), Matale East (2), Morawak Korale (2), Pundaluoya (2), Rakwana (1), Pussellawa (2), and Udapussellawa (2). 38 estates also made 45 general enquiries, including a number from the following additional districts: Balangoda, Galle, Hewaheta Lower, Kadugannawa, Kalutara, Ratnapura and Rangala.

In most cases, tea bushes are not found to be affected by Shot-hole Borer alone, and it is common in specimens examined to find several other factors also involved in contributing towards poor condition and sometimes even complete deterioration of bush frames. Commonest amongst these perhaps are die-back and wood rot, starch deficiency, nutritive deficiency, Eelworm, partial burial of the frame caused by soil displacement on slopes, and possibly the continued plucking of weakened bushes in low yielding fields. The number of factors which can be involved in contributing towards weakened bush frames, through a gradual and cumulative process of repeated occurrences over a period of years in a tea bush's history, may perhaps only serve to emphasize the fact that while there are conditions necessitiating immediate control, there are also conditions which at one particular time, although they may appear unimportant or appear to be doing insufficient damage to make control at the time considered worthwhile, nevertheless add up collectively and cumulatively over years, eventually to conditions that assume major importance. Whether it is economically worth while or not, in doubtful cases, to institute control measures, is often difficult to decide, but early prevention is perhaps better in such cases than a late cure.

8.3 Mites—Attacks by mites of the various species found on Ceylon tea were recorded on specimens sent by estates to the laboratory, and also in the course of estate visits, from 34 estates in 20 districts. The number of occurrences recorded for particular species in the districts concerned was as follows.

(*a*) *Yellow Mite*—Dickoya (5), Dickoya Lower (1), Dimbulla (8), Galle (1), Kelani Valley (1), Kelebokka (1), Knuckles (1), Maturata (2), Morawak Korale (1), Pussellawa (1) and Ramboda (1).

(*b*) *Red Spider Mite*—Dickoya (2), Dickoya Lower (1), Dimbulla (3), Dolosbage (2), Galle (1), Knuckles (1), Matale East (1), Rakwana (1), and Ramboda (1).

(*c*) *Scarlet Mite*—Dickoya (3), Dimbulla (4), Knuckles (1) and Maskeliya (1).

(*d*) *Purple Mite*—Dimbulla (1), Galle (1), Hewaheta Lower (1) and Kelani Valley (1).

15 estates also made additional general enquiries.

8.4 Other Pests—Reports included the following : Figures in brackets are in respect of number of estates in each case.

Aphids (2), Army Worm (6), Bag Worm (4), Ants of various species, not Termites (5), Capsid Bug (2) Cut Worm (2), Meadow Eelworm (33), Helopeltis sp. (1), Tea Leaf Roller (4), Tea Leaf Miner (1), Lobster Caterpillar (3), Lygus Bug (1), Leeches (5), Mealy Bug (3), Nettle Grub, various species (3), Red Slug (3), Red Borer (5), Ragmus Bug (2), Scale Insects, various species (5), Twig Caterpillar (1) Termites, various species (10), Thrips (2), Tussock Moth (4), Weevil (1), White Grub (2).

Meadow Eelworm was recorded in tea root specimens from 31 estates on 36 occasions, the number of cases recorded during the year for each district concerned being as follows : Dickoya (7), Dickoya Lower (2), Dimbulla (13), Hantane (2), Kotmale (1), Maskeliya (1), Morawak Korale (2), Pundaluoya (1), Nuwara Eliya (2), Pussellawa (1), Ramboda (1) and Udapussellawa (3).

17 estates also made additional general enquiries.

9 Physical and Cultural Conditions

9.1 Failure of VP cuttings in nurseries and Collar Rot in clearings

Circumstances under which failure or unsatisfactory growth of VP cuttings in nurseries and also causes of cases of collar rot occurring in young plants in clearings were referred to in the previous Annual Report for 1963. In 1964, 32 estates in 13 districts reported difficulties in establishing cuttings in nurseries, and 24 estates in 19 districts had casualties amongst young plants in clearings caused by collar rot. There were 5 more estates reporting nursery difficulties, and 10 fewer estates with collar rot casualties than in 1963.

9.2 Other relatively common types of cases reported were die-back and wood rot (28 estates), and fertilizer and chemical scorches (22 estates).

9.3 Several cases of die-back and non-recovery from pruning have been enumerated during the course of the year, but in no case has it been possible to state that these are due to starch deficiency alone. Examinations of the roots have also shown that there is no direct correlation between the amount of starch present and the condition of health of the bush. It is equally possible to find by the iodine test, total starch deficiency in some roots of perfectly healthy bushes, and, conversely, strong starch iodide reaction in roots of unhealthy bushes and even those in an advanced state of debilitation.

10 General Enquiries (Excluding Specimen Examinations)

10.1 Vegetative propagation techniques and clones

83 estates made general enquiries on VP problems. These dealt principally in regard to the general techniques and methods of vegetaive propagation, the selection of clones suitable for particular districts, yield and quality characteristics, resistance and tolerance to eelworm, purchase of cuttings, and sources of supply of approved clones.

10.2 Fertilizer appication, fertilizer chemicals and mixtures, and fertilizer policy

150 estates made enquiries under these headings during the year, and further enquiries were received from Agencies and other sources, including a number abroad. Although new recommendations for the manuring of mature tea had been published in the Tea Quarterly dated September 1963, and quite a large number of estates have followed these recommendations, there are still some numbers that adhere to ratio methods and adopt a replacement principle. The response to the suggestions made in the above Tea Quarterly in connection with experimental manuring have been also somewhat disappointing, very few estates appearing to have taken up these suggestions, or if some larger numbers than are so far known have actually done so, there has been no notification made to the Institute. With the fertilizer import position having imposed a shortage during the year, and also with other import restrictions, many estates have also sought to cut down on fertilizer expenditure wherever possible, and this has been manifest in several enquires from both estates and agency houses in regards to means of doing so without affecting yield and quality. In this respect, the effect on yield and quality of total omission of Saphosphosphate from standard NPK mature tea fertilizer mixtures over a prolonged period of time has not been definitely established, but under the current circumstances, it has been considered safe to suggest that phosphate may be omitted for at least one year and possibly two. The question of potash omission is regarded as a much more risky measure, and it is considered unwise to omit this if an estate has a history of potash deficiency. Where this is not the case, the question of the past history of potash fertilizing may be a deciding factor. It is not possible

at the moment to quote experimental evidence in support of any proportion of potash to nitrogen, for example, which might be "safe," but it might be safe to generalise and say that the Institute would not favour total omission of potash even for one year. Where the issue has been in doubt, it has been felt advisable to retain potash in the mixture, particularly at lower elevations, if economics will permit, at least at the T 700 porportion ; but if total omission is required, it is strongly suggested that a few fields, continuing to receive potash, be retained as an experimental comparison with fields of equal, or as near equal as possible, yield performance. The question of whether or not, under the economic circumstances, nitrogen may be reduced is probably one which only an estate can decide for itself, depending on what value it places on its nitrogen levels of application. The Institute's own trials suggest that most tea is undermanured, while it is also clear that some estates ought to be yielding more than they are at present if level of nitrogen were the main factor effecting yield. This question can only be answered in the form of experiment as suggested in the Tea Quarterly of September 1963.

10.3 Weed Control

Probably more interest in the use of herbicides has been felt by estates this year than last as a result of the necessity, under present economic circumstances, to cut down as much as possible on costs of production, and where manual weeding costs are unduly high. In certain areas, with labour shortage problems, satisfactory weed control by chemical means has assumed most importance. The number of enquiries on the subject which came in during the year, however, were surprisingly few, there being only 22 estates and 10 non-estate enquiries involved, and it is possible that this small number of enquiries may have been due to comparative lack of experimental work having been done by the Institute in the past on the subject. More experimental work has, however, been undertaken this year, with results that are given in the annual report of the Agronomy Division. At the present time of writing, (February 1965), some interesting information has emerged in regard to a method of weed control, using simazine and Gramoxone, which has been adopted by a Tea Company with considerable success in East Africa. The method has not been tried, as far as is known in Ceylon, but a few estates have already been encouraged to try it experimentally, and any other estates are invited to enquire, if they wish, for further details. Of particular interest is the report that where the method has been adopted in East Africa, the overall labour requirements were reduced to the remarkably low figure of 0.5 head of labour per-acre.

10.4 Advisory Literature and other Publications

247 requests for leaflets and other TRI publications were received and answered during the year from various sources including students at Universities, Technical Training Colleges, and other Educational Establishments, as well as from several others including sources abroad. 176 requests were received and answered in English and 71 in Sinhala. (There is no Tamil typewriter at the Institute).

10.5 Other general enquiries (excluding specimen examinations)

The following additional number of enquiries not yet mentioned were also received and answered.

pH and pH reduction in the field (2), Blister-blight control (6), Compost making (1), Defoliation of tea (2), Eradication of tea in areas to be abandoned (1), Forking (2), Mossing and Ferning (11), Manurial trials (4), Pruning (3), Plucking (1), Replanting and Rehabilitation (6), Ring-barking of shade trees (6), Packing and storage of tea seed (4), Marigold seed supply (1), Tea Seed

Bearers (2), Soil Erosion (1), Soil analysis (4), Suitability of land for tea planting (2), Supplying of vacancies (4), Termites (5), Requests for photographs (7).

11 Symposia

Four symposia, all on vegetative propagation were held during the year at Passara (14th July), Badulla (16th July), St Joachim Estate, Ratnapura (16th September), and Kandy (4th December). Attendance at these meetings was generally high, and they were considered very successful. It is planned to hold a considerably larger number of these in various districts in the forthcoming year, and to hold meetings for each individual P.A. district as often as can be managed. These will enable a much closer touch to be kept with planting problems in each district than has hitherto been feasible at general conferences in which all P.A's have been collectively involved, and it may result in general conferences being held, in the future, with less frequency than formerly, but always with due regard, however, to the value of exchange of information with planting and scientific interests abroad whenever occasion demands.

12 Exhibitions

The Advisory Division, in co-operation with other divisions of the Institute and also the Tea Propaganda Board and Tea Control Department in Colombo, contributed exhibits for the following exhibitions :

1 The Independence Day Commemoration Celebrations Industrial and Agricultural Exhibitions held at Galle from 4th to 8th February.

2 The Exhibition Train touring the country during December.

3 The Kotmale Rural Development Exhibition held at Hadunuwewa on the 18th and 19th December.

13 Transfer to New Quarters

Space made available at St Coombs for Advisory Division use was enlarged by more than twice its previous size, from two rooms to four, and now occupies premises formerly occupied by the Administrative Division, the transfer having been made on 15th October, and the Vegetative Propagation Division now occupies the old Advisory Division quarters.

ANNUAL REPORT OF THE DISTRICT ADVISORY OFFICER—UVA FOR 1964

L. M. de W. Tillekeratne, BSc, M Ed

Staff

The Officer-in-Charge, Vegetative Propagation was transferred to St Coombs on 1st November 1964, and he was replaced by Mr D. N. R. Wijewardena, as assistant to the Advisory Officer from that date. With the transfer of the OIC, VP, the sub-station has now come under the jurisdiction of the Advisory Department, although the clonal proving section and trials on VP are still controlled by the Adviser in Plant Propagation. Temporary clerical assistance continued to be available.

Buildings

The extension to the present laboratory was completed, and gives sufficient work space for the Advisory Officer.

Correspondence and Visits

440 letters were received.

454 letters were despatched.

135 estate visits were made during the year, made up of 87 advisory visits, 41 visits in connection with field experiments on estates and 7 visits in connection with the inspection of land for the new Uva sub-station. 11 PA meetings were attended. 25 Superintendents and Assistant Superintendents visited the Sub-station on advisory matters.

General

The climatic conditions throughout the year have been abnormal. We registered only 1.92″ of rain on 5 wet days in May as against 5.3″ on 13 wet days in May 1963. October, November and December were rather poor months for planting, with the result that plantings of clearings were considerably delayed even into January 1965. Tea Tortrix, nettle grub, and mites normally pests during dry weather, were prevalent almost throughout the year, and caused considerable damage.

Disease, Pests and Deficiencies

The following number of cases were dealt with in the course of examination of specimens in the laboratory, during estate visits, and through general enquiry from estates concerned.

Poria hypolateritia (9), *Ustulina deusta* (*zonata*) (4), Drought (4), *Fomes noxius* (8), *Rosellinia arcuata* (2), Meadow eelworm (5), Shot-hole borer (9), Red Borer (2), Mites (4), Nettle Grub (3), Tea Tortrix (7), Minor insect pests (15), Fertilizer scorch (6), Potash (9), Fertilizing general (11), Boron (3), zinc (10), Magnesium (6).

In addition 93 soil samples from nursery and proposed new clearings were tested for pH.

A peculiar kind of scorch was observed, on two estates in the Bandarawela district, one estate in Passara, and one in Namunukula. The symptoms were red scorched patches on the leaves, with no definite pattern, and were confined to vigorous growing clonal material. No primary fungi were detected, and this condition was attributed to sun-scorch, brought about by a period of very dry weather which followed a period of forcing weather. The foliage just after the period when growth had been rapid may have been rather more tender than usual, especially on quick growing clones, and have been more susceptible to sun scorch when subjected to the sudden very hot dry conditions which followed. These scorched patches were invaded by the secondary parasites, grey and brown blight, which gave the characteristic symptoms observed.

Outbreaks of tea tortrix were recorded, even on areas not sprayed with Dieldrex almost throughout the whole year. This may be due to the unusual weather conditions that prevailed during 1964. Incidence of root diseases, especially Brown Root and *Ustulina* were on the increase, and this may have some relationship to removal of shade in the past, without ring-barking.

Physical and Cultural Conditions

(*a*) *VP Nurseries*—Failures appeared to be due mostly to the use of heavy textured soils, with poor drainage. On the sub-station, and on a few estates, the use of high shade nurseries were introduced, following the success obtained by Gonakelle Group last year. This type of shade seems promising, if propagation is started in late February or early March after the heavy NE rains, as otherwise drip damage can be considerable.

(*b*) *Pruning*—The general problems of fields taking a longer time to recover after pruning, a few casualties and more die-back continued this year too. With the unusual weather experienced and abnormal cropping months, timing of pruning and the type of prune during the year has been a problem. The whole question of the time, and type of pruning needs investigation.

(*c*) *Shade*—The question of shade, especially in the new clearings is still a problem. More field trials are necessary on this aspect.

Fertilizer Application, Fertilizer Chemicals and Fertilizer Policy

Most advice still continues to be on the foliar application of zinc and magnesium. Advice was given to a few estates on their general fertilizing programme especially where their estimates for 1964/65 were concerned. The high prices of fertilizer, and difficulty of obtaining it have discouraged to some extend the experimental program advocated by the Institute to determine requirements for each estate.

Field Trials on the Sub-Station

(1) *Pruning Experiment*—(1) The preliminary pruning started in October 1963, and reported in the Annual Report for 1963, was completed in 1964. 3 types of pruning under test were (1) Control-low cut across (2) Rim-lung pruning (3) Pre-pruning.

This preliminary trial strongly indicated the necessity of leaving lungs, especially when giving the first prune to VP tea. The normal method of leaving rim-lungs was superior to leaving centre lungs.

(2) *Pruning Experiment*—(2) This experiment conducted on an old spacing experiment started in October 1963, and reported in the Annual Report for 1963, was concluded in December 1964. Treatments were(*a*) 3 clones (TRI—2024, 2025 and 2026), (*b*) 3 methods of pruning (same as experiment 1), (*c*) Different periods of resting before pruning. Pruning of the experiment was started on 19th February 1964. First tipping started on 2nd July 1964. 2nd tipping was done on 20th August. Plucking records of the different plots are being kept. The pruning was a low cut across clean prune, and about 250-300 leaves were left on the lung treatments.

The mean starch in root samples, as % of dry weight sample expressed as true dextrose for all plots in November 1963, was 11.37% and February 1964 was 13.63%. These figures are statistically different at the 0.1% point as calculated by the Student's "t" distribution for paired variates.

There appeared to be very little difference between resting and no resting on the starch reserves. Resting too had no effect on die-back and subsequent recovery of the bushes. Types of pruning gave a significant difference in die-back. The lung pruned bushes were superior in this respect to clean pruning. There was no difference between pruning treatments on the subsequent recovery of bushes. No clonal differences were observed, and all clones seemed to behave in a similar way.

These experiments were conducted in conjunction with the Plant Physiologist.

Estate Field Trial

Queenstown—Hali-Ela—The experiment to determine (*a*) the proper time of the year for the 1st pruning of VP tea in Uva (*b*) the possible causes for the peripheral scorch which appears on the 1st shoots after pruning (*c*) effect of resting, which was started in October 1963 was concluded in the middle of 1964. This experiment was conducted on a patch of clonal tea (clone TRI 2024) in the 1961 new clearing on Queenstown Estate. Treatments are reported in the Annual Report for 1963.

The mean % starch of roots samples in early April per plot expressed as true dextrose for rested and not rested bushes were 11.92% and 9.22% respectively. The difference was not significant as calculated by the Student's "t" distribution for paired variates. The mean % starch of roots for plots sampled in October 1963 was 10.50%. There was no difference between the starch content of bushes sampled in October 1963 and April 1964. Plots pruned in October 1963 recovered with very little die-back (average of 130 g per 25 bushes) and no casualties, while about 85% of the bushes pruned in April 1965 failed to recover entirely, and this area had to be replanted subsequently. From the results of this experiment, starch reserves do not seem to be the main factor in controlling recovery from pruning and die-back. We can definitely conclude that the first prune on VP tea should be avoided during the months of March and April, and if pruning is done at this time of the year, it is essential to leave lungs. We also have to investigate further to find out the factor, or factors that contribute towards recovery from pruning, and eliminate die-back.

This experiment was conducted in conjunction with the Agricultural Chemist and with the co-operation of the Plant Physiologist.

Batawatte Group—Madulsima—An experiment to determine the effect of shade on new clearings was started in October 1963, and was reported in the Annual Report for 1963.

From the casuality figures obtained to-date, there seems to be very little difference between shaded and unshaded plots. In addition to shade trees, a bush green manure, *Crotalaria*, was planted in between tea rows in the shaded plots. This experiment is still continuing.

Ury Group—Passara—The time of pruning experiment envisaged in 1963, and reported in the Annual Report for 1963, was started from January 1964. 90 bushes were pruned per plot on Ury Division and Agratenne Division, around the 15th of every month except June and November. The pruning done was a medium clean prune.

Root samples for starch determination were collected at the time of pruning. Assessments on (*a*) The number of days from pruning to tipping (*b*) Die-back (*c*) Tipping weights, are being recorded.

Unfortunately the roots sampled for starch determinations from the months of January and February were misplaced and these figures are not available. The starch figures for the other months are given in Table 1.

TABLE 1—*Total available carbohydrates as % dry weight sample expressed as true dextrose (Mean values for replicates)*

	March	Apr.	May	July	Aug.	Sept.	Oct.	Dec.
Ury Division	6.37	6.05	4.28	7.86	9.22	11.14	9.41	8.82
Agratenne Division	5.43	4.54	5.94	8.76	7.04	8.46	8.99	10.89
Average	5.90	5.29	5.11	8.31	8.12	9.80	8.69	9.86

(Significant Difference at P=0.05=2.46 and at P=0.01=3.33)

The assessments are not completed, and the experiment is continuing. The results to-date indicate (*a*) A sudden rise of carbohydrate in roots towards the latter part of the year (*b*) Little difference between the two locations in terms of carbohydrates although Agratenne Division is about 1500 feet below Ury Division. (*c*) The medium clean prune adopted is unsuitable on these divisions, as it results in very late recovery, die-back, and even casualties.

The co-operation of the Plant Physiology Department in analysing the root samples for starch is acknowledged.

Demodera Group—Demodera—The experiment to determine the effects of foliar applications of zinc sulphate on Demodera Group new clearings, envisaged in 1963 and reported in the Annual Report for 1963 was started at the beginning of the year. Pre-treatment records for variation in plots started in early February. 4 such rounds were recorded, and the first spraying of zinc sulphate was given on March 3rd. This was followed with a second spraying on June 19th, and a third application on October 30th. The final spray round will be given in January/February 1965. Weekly plucking were done, and fresh weight yields per plot recorded. Banji percentages were done every fourth plucking. The plots were sprayed at the rate 50 gallons spray solution per acre.

The results to-date are presented in Table 2.

TABLE 2—*Mean cumulative yield of fresh weight per plot for all clones after 47 plucks in oz corrected for pre-treatment differences*

Treatments	1	2	3	4	5
	790.2	903.2	863.9	873.4	930.2

Significant Difference at P=0.05=55.4

The results so far indicate (*a*) significant difference of all zinc treatments over the control (no zinc sulphate) (*b*) There seems to be no difference between 10 and 20 lb per acre (*c*) All three clones seem to respond in a similar manner, although initially TRI clone 2025 did not show any visual symptoms of zinc deficiency unlike Miriekella 6 and 14. This experiment is continuing.

This experiment is conducted in conjunction with the Agricultural Chemist.

Welimada Group

This experiment was reported in the Annual Report for 1963. All treatments were given in 1964. The following assessments were done on bushes after the drought in November 1964. (*a*) Diameter of main stem (*b*) Number of branches per 5 bushes per plot. (*c*) Height of bushes. From the results so far obtained treatments 1 (cutting the bushes in December/January 1963/64 and light plucking until May/June 1964) and 4 (continuous light plucking the bushes with the N.E. rain in 1963 with no cutting back) have given the best bush formation and quick cover of the ground.

New Uva Sub-station

A committee was appointed by the Planters' Association (Uva) comprising of Mr W. T. Williams, Mr R. I. H. Scott and the District Advisory Officer for the purpose of selecting a suitable site to locate the new Uva sub-station. The committee inspected an area on Yelverton Estate, which was suitable from all aspects, except unfortunately the pH of the soil was unfavourable and this area had to be abandoned. Because of the kind co-operation of the Manager of Ury Group it has now been possible to select an area on Agratenne Division of Ury Group, as a possible location for the new sub-station. The Committee has selected an area of 144 acres at an elevation of between 2000-3000 feet comprising fields of both good and bad tea. This project is expected to start in 1964. In this connection our sincere thanks are due to the Superintendent of Yelverton Estate and Manager, Ury Group for their kind co-operation.

Extension Activities

Two symposia on all aspects of vegetative propagation of tea were held under the auspices of the Passara and Badulla sub-district PAs. The object of these meetings were to disseminate to the planting community techniques that had proved successful in the vegetative propagation of tea in the District. For this purpose two techniques were tried out, for comparison. At the Passara Sub-district meeting there were two panels of 4 members each, a questioning and answering panel, while at the Badulla sub-district meeting there was only an answering panel, and all questions were asked by members of the audience, through a questioning master, who was also the Chairman of the meeting. The panels consisted of senior planters with wide experience in Vegetative Propagation and clearing work. Both meetings were very well attended.

The symposium at Passara was a great success, because each member of the questioning panel selected a portion of the programme, which was distributed earlier, to prepare questions before the meeting, so as to cover all aspects of his particular choice. This enabled the meeting to proceed without any break, and all aspects of the programme were fully covered and discussed. Unfortunately this was not the case with the Badulla meeting, because there were no prepared questions on the programme distributed, and the meeting tended to lag at times, and it was left to the question master to ask most of the questions. At this meeting, too, however, all aspects of VP were discussed, and it was successful, although not quite up to the standard of the Passara meeting. The proceedings of both meetings were tape recorded, and the minutes of the Passara meeting, at the request of the Uva PA Chairman have been distributed throughout the whole district.

Acknowledgements

Our sincere thanks are due to the Managers of Ury, Demodera, Battawatte, Welimada and Queenstown, for their kind co-operation in helping us to carry out our extension experiments, to the members of the sub-committee for selecting the new sub-station site, to the Manager of Gonakelle Group for all his help in maintaining the present sub-station, and to the Heads of Research Divisions for their help and guidance.

REPORT OF THE SUPERINTENDENT OF ST COOMBS ESTATE FOR 1964

J. G. G. Tennekoon

Staff

There were two resignations from the staff of St Coombs during the year. The Head Teamaker Mr G. M. D. Silva left the estate on 28th November 1964. The Senior Assistant Mr V. A. Fernandez is acting till the permanent Head Teamaker is appointed. The Midwife Mrs L. T. Moorthey left the estate on 31st May 1964. Mrs K. Aslin Nona has been appointed in her place.

Acreage as at 31st December 1964

	A	R	P
Tea in bearing	222	0	33
Llan Thomas and 14B area—1961 planting	8	3	17
Field No 7 & No 8—1962 planting	10	1	00
Field No 7 & No 8 TRI—experimental planting	12	1	14
Field No 2 & No 7—1964 planting (rehabilitation)	15	1	00
Field No 3—1965 planting (rehabilitation)	15	0	00
Area reserved for Clonal cuttings	2	2	00
Tea seed bearer areas	0	0	09
Nurseries in Field No 1, 12 & 14A	3	0	08
Fuel Clearings etc	29	1	38
Buildings, roads, gardens etc	62	1	22
Land unsuitable for planting	40	3	22
	422	1	03

No changes were recorded.

Weather (Estate gauge)

There has been very uneven distribution of rainfall throughout the year with very dry weather in the first half.

Rainfall to the end of June was 22.82 inches as compared with 35.25 inches for the same period in the previous year and a decennial average of 39.99 inches. Rainfall recorded from July to December was 56.94 inches as compared with 48.25 inches for the same period last year and a decennial average of 49.44 inches. There were a number of prolonged dry spells in the second half of the year.

Another mild South West Monsoon was experienced and the North East Monsoon failed completely. A cyclone stuck the Northern and North Central parts of Ceylon on the 22nd of December causing severe damage in those areas. No damage occurred in the tea growing areas, but a considerable amount of tea, due for shipping, was lost from Trincomalee Harbour.

Crop

Because of unfavourable weather conditions we fell short of the estimated crop of 330,000 lb by 23,283 lb.

The yield per acre for the year was 1,430 lb. The monthly intake of crop throughout the year was as follows :

Month	lb Made Tea	Yield per acre
January	32,238	152
February	22,982	112
March	23,615	114
April	29,828	145
May	30,974	147
June	35,699	168
July	17,000	77
August	24,210	112
September	21,140	95
October	25,641	115
November	17,301	76
December	26,089	117
	306,717	1,430

The highest monthly crop was harvested in June when the average yield for the estate was 168 lb per acre.

A record crop was harvested in January when the yield was 152 lb per acre. Poor yields were obtained in July and November.

No Sunday plucking and cash plucking was resorted to during the year.

Prices and Total Crop Sold

Year	Total crop Sold lb	Gross price cents	Nett price cents
1964	283,745	313	243
1963	294,101	261	219
1962	285,794	268	223

There was an increase of 24 cents on the nett average price per lb for the year and the prices compared very favourably with the high-grown average.

Cost per lb

	Cents		
Year	1964	1963	1962
Estimate	152.95	147.31	156
Actual	156.89	140.63	145

Profit on Estate Working

1964	Rs. 232,564*
1963	Rs. 222,077
1962	Rs. 233,443

* Subject to verification by the auditors

Capital Expenditure

1964 .. Rs. 163,771 (51 ct per lb)*

1963 .. Rs. 40,704 (12 ct per lb)

1962 .. Rs. 130,902 (43 ct per lb)

The main items of capital expenditure were :

New Clearing

	Spent	Subsidy
1962 planting — 10 acres —	Rs. 10,518	Rs. 58,395
1963 planting —	—	—
1964 planting — 10 acres —	18,532	2,715
1965 planting — 13 acres —	3,287	—

Plucking

7-8 day plucking rounds were maintained throughout the year and the standard of leaf harvested was satisfactory. The average per plucker for the year was 30 lb compared with 34 lb in 1963 and 30 lb in 1962.

Estate Roads and Paths

Routine maintenance of field roads, footpaths and estate roads was carried out. Terracing of roadside drains was done where necessary. Roads and paths are in order.

Fuel Clearings

Routine maintenance work was done during the year. 3,000 gum plants of the variety *Eucalyptus saligna* were put out in the big ravines during the South West Monsoon. Demand for firewood from the increased TRI Staff resulted in the purchase of 505 yards of firewood from surrounding estates. Demands of all Institute and Estate Staff were met.

Boundaries and Ravines

All boundaries are in order and were regularly cleaned and maintaind throughout the year.

Weeding

The over-all cost of weeding for the year was Rs. 9/04 per acre. A regular monthly round was completed, 71 acres being weeded on contract and the balance on estate account. All weeds were transported away from the field.

Pest and Diseases

Blister Blight:

Regular spraying rounds were done when periods of unfavourable weather prevailed. Mist-blowers were used with 4 ounces of Perenox in two gallons of water per acre. Knapsack sprayers were used in fields recovering from pruning.

* Subject to verification by the auditors

Scarlet and Yellow Mite:

In February a build-up of yellow mite was observed in Fields No 4 & 9 (Fields in their first year of plucking). These fields were sprayed with Kelthane at 1½ pints in 10 gallons water per acre using mist-blowers.

Tea Tortrix:

In April a moderate attack of Tortrix was observed in Field No 4. As a build up of tortrix was anticipated the field was sprayed with Arkotine at 4 pints in 10 gallons water per acre using mist-blowers. More Tortrix was observed this year than in past years.

Poria:

A few small patches in Field No 5 were fumigated with Shell DD.

Loranthus:

Loranthus growing on *Grevillea* have been removed in all fields.

Pruning

The following fields were pruned during the months indicated against each field :

No 1	—	10 acres	..	August
No 3	—	16¼ „	..	September-November
No 5	—	19¼ „	..	May-July
No 13	—	19 „	..	July-September
		64½ acres		

The frames in Field No 3, 5 and 13 were very poor carrying twisted branches and many old large knots. A clean prune was done and saws were used to cut out all poor branches and old knots.

Rim lungs were left when Field No 1 was pruned as this is a field with clonal tea and some blocks received their first prune. The field is also infested with meadow eelworm. The lungs were removed after budbreak.

A pruning experiment was laid down in Field No 3. This field carried bushes with very poor frames. A comparison is being made between a hard clean prune and a collar prune.

Supplying and Nurseries

Plants for supplying in 1965 were put down in the period March/April/May.

For observation a comparison was made between cuttings in pots containing sub-soil and Guatemala soil. The plants in Guatemala soil have grown better.

T 65 mixture was applied at 1 oz/gal/sq yd/per fortnight, and was watered on.

The following quantities of plants are available for 1965 supplying :

Clone	No	No of Plants
TRI	26	3,500
,,	777	3,900
,,	2022	350
,,	2024	9,100
,,	2025	3,200
,,	2026	400
,,	2043	4,000
,,	2142	15,820
DT	1	31,500
MC		200
		71,970

Mossing and Ferning

Frames in Field No 5 and No13 were sprayed with Limbux at 1½ cwt per acre. A comparison of budbreak and growth in sprayed and unsprayed blocks is being made by the Plant Pathology Division.

Fertilizer

Fertilizer was applied during 1964 in keeping with TRI recommendations (*Tea Quart.* **34**: Part III).

All fields fell into yield category 3, and an average of 162 lb of nitrogen per annum was applied in 1964.

Fertilizer was broadcast in both rows and the number of applications averaged four per field.

All fields except those due for pruning were drench sprayed during March with a mixture of 7 lb commercial Epsom salts, 1 lb zinc sulphate in 15 gallons water applied at a rate of 100 gallons per acre.

Green manure and Shade Trees

Low shade consisting mainly of dadaps was lopped twice during the year. Dadaps were resupplied in two pruned fields No 5 and No 9 where the dadap rows stood eight tea rows apart.

Cootch and Illuk

Isolated patches of Cootch grass and Illuk in all mature tea areas received attention during the year and are under control.

New Clearings

1962 Clonal Planting—Field No 7-6 Acres; No 8-4 Acres

Routine weeding and spraying was done. Fertilizer was applied 6 times during the year using the T 200 mixture at ¾ oz per plant per application.

Drains were cleaned out, dadaps were lopped twice during the year and boundaries and ravines attended to. These clearings were plucked lightly in January and February. In April it was plucked on a 7-day round and this continued to the end of the year. No 7 field yielded 1,111 lb per acre and No 8 field yielded 801 lb per acre to the end of the year. All vacancies in these fields were re-supplied in June/July.

This clearing was set back initially due to the non-removal of the entire polythene sleeve at time of planting and was also found to be heavily infested with eelworm in one block of Clone TRI 2024. Approximately 1½ acres of the block was uprooted in December and sown with Marigold seed. The area will be replanted with Clone TRI 2142 during the South West Monsoon period in 1965, after fumigation if the eelworm count is still high.

1964 Clonal Planting—Field No 7—7½ Acres; No 2—7½ Acres:

11¼ Acres of this clearing was planted up by the estate with 6 acres in No 7 Field and 5¼ acres in No 2 Field.

The following areas were given over to the TRI Divisions :

Field No 7		Acres
Plant Pathology	..	1½
Field No 2		
Plant Physiology	..	1½
Agronomy	..	¾
		2¼

1964 Clonal Planting—Field No 7—7½ Acres; No 2—7½ Acres (Continued)

The Gautemala grass in this clearing was cut at ground level in January and lateral drains were cut approximately 40 ft apart and on gradient of 1; 120;. The planting distance was 4 ft × 2 ft.

Planting commenced in June and was completed in August. Rows of dadaps were established 20 ft apart.

A round of weeding was completed each month and a regular spraying against Blister blight was done in unfavourable weather. Plants were fertilized with T 200 mixture in July, September and November at ½ oz per plant.

The plants put out were as follows :

	Clone	No	No of Plants
Field No 7	TRI	2023	16,194
	,,	2024	1,575
	,,	2025	1,820
	,,	2026	1,650
	DT	1	2,210
			23,449

Field No 2	TRI	26	500
	,,	740	272
	,,	777	900
	,,	2016	134
	,,	2022	455
	,,	2024	3,859
	,,	2025	4,343
	,,	2039	226
	,,	2026	50
	,,	2142	10,228
	DT	1	1,112
	,,	95	1,864
	E	727	2,507
			26,490

1965 Clonal Planting—Field No 3—15 Acres

Guatemala grass lopped three times during the year at 14 inches above ground level. The area was fertilized after each cut at 4 cwt grass manure per acre, per application, the fertilizer being braodcast.

The following areas have been taken over by the TRI Divisions :

VP Division	—	1½ Acre
Nematology Division	—	½ ,,
Plant Breeding Division	—	¼ ,,
		2¼ Acres

Factory and Machinery

Messrs. H. W. Hammond & Co made their annual inspection on 24th February, 1964 and the recommendations made in their report are being carried out.

Lofts:

108" Aerofoil fans have been installed replacing the old 72" Wing type fans.

Alterations to the withering system and bulking chamber have been completed satisfactorily.

Drier:

The new Davidsons 4 ft drier has been installed. This machine is in operation since November and is working well.

Sifting Room:

A new Chota sifter was installed in October and is working satisfactorily.

Factory Electrification:

Messrs Walker Sons & Co Ltd have completed the factory electrification programme and all machines are now controlled with A C Motors.

Manufacture

Manufacture during the year was carried out mainly with a 4 roll programme as follows : *ie* 4 rolls of 30 minutes duration (120 min rolling). Four periods of rollbreaking of 10 minutes duration (40 min rollbreaking) with 2½-3⅓ hours fermentation, charges every 50 minutes. Order of firing 2, 1, 3, 4 big bulk.

The percentage of dhools obtained from the above programme were as follows :

1st Dhool	..	12%
2nd ,,	..	22%
3rd ,,	..	32%
4th ,,	..	24%
Big Bulk	..	7%
Evaporation	..	3%
		100%

Graded Percentage

	1964	1963
Broken Orange Pekoe ..	67.31	70.40
BOP Fannings	14.21	13.87
Fannings		1.72
Broken Pekoe		2.02
Broken Mixed	7.19	5.45
Dust—1	5.31	5.18
Dust—2		.80
Experimental Teas		.56
Fannings—2	5.98	
	100.00%	100.00%
Out-turn of made tea to green Leaf	23.01%	22.43%

Rotovane Manufacture

Rotovane manufacture has gone on right through the year and 26% of all tea manufactured consisted of Rotovane tea.

Withering troughs were in use regularly during the year.

Labour

53 children over the age of 14 years were taken on a cash basis, during the year, with 9 incoming brides being registered.

Health was generally good.

The labour force co-operated reasonably well with the management throughout the year.

	Men	Women	Non-working children	Total
Working labourers on estate as at 31st December, 1964	255	253	—	508
Non-Working labourers (Pensioners) ..	26	27	—	53
Non-working children	—	—	630	630
Total estate population	281	280	630	1191

Working labourers numbered 1.76 per cultivated acre and the percentage of out-turn was 89%, 33.54% of all labour employed was used by the Institute for experimental work.

Buildings and lines

The total number of units, all up to Government standard, is 42 sets or 262 rooms. The number of workers per room is 1.94 and the number of souls per room is 4.54.

During the year white-washing was done and all necessary minor repairs completed.

A further two sets of lines, P A Health Scheme Plan No LQ/40 cottage type was completed.

All minor buildings on the estate are in satisfactory condition.

Visiting Agent

Mr P. R. U. Easteal visited the estate on the 24th April 1964 and 22nd October 1964.

Clonal Blocks

During the year 1,326,685 cuttings were sold to estates all over the Island. It is hoped that other estates will endeavour to meet the demand of the more popular clones in the near future.

General

The year under review has been a very satisfactory one and we look forward to a good season in 1965.

REPORT OF THE SUPERINTENDENT OF ST JOACHIM ESTATE FOR 1964

G. S. Muttettuwegama

Staff

Mr G. S. Muttettuwegama assumed duties on 21-12-64 and Mr Andrews left the estate on 28-12-64, after handing over. Mr M. S. W. Wijeratne took up appointment as Head Teamaker on 1-12-64.

Acreage as at 31st December 1964

	A	R	P
Mature tea in full bearing	286	2	14
Immature tea (TRI expt) 2nd year ..	0	2	29
New Clearing	*10	0	00
Reconditioning—2nd year ..	8	0	35
Nurseries	1	3	11
Old seedling rubber (just being planted into tea)	10	0	00
Paddy lands	29	1	24
Buildings & roads	59	3	35
Jungle & wasteland	5	2	16
Labourers gardens	3	1	22
Areas not in possession (encroachments)	0	2	00
	416	0	26

*Out of the 20 acres shown under old seedling rubber in the previous year, approximately 7 acres have been planted in VP tea both by the estate and TRI. A balance of 3 acres is to be planted up by the TRI.

Weather (estate gauge)

	Inches	Wet Days
Registered in 1962	134.79	213
„ „ 1963	174.22	246
„ „ 1964	185.28	208

In January and February, the rainfall was 5.76″ less than the previous year. In March and April the rainfall was 3.24″ more than the previous years but the distribution was about the same. In May, however, the rainfall was considerably over that of last May, an increase of 19.38″ and the distribution was uneven. In June there was less rainfall but the distribution was better.

In July rainfall was heavy, 26.77″, 6.55″ more than the previous year, accompanied by very strong winds. In August and September rainfall was less and winds were fairly strong in the afternoons.

In October and November rainfall was 7.83″ more than the previous year and considerable damage was caused to roads and culverts.

In December the rainfall recorded was low (3.33″). Heavy mist was experienced in the mornings with the days being hot and the nights chilly.

Crop

	1964		1963	
	Made Tea lb	Green Leaf lb	Made Tea lb	Green Leaf lb
Estimated	315,000	1,575,000	302,000	1,313,000
Secured	334,183	1,623,833	339,932	1,725,986
Yield per acre	1,167		1,174	

The monthly intake of Made Tea during the year was as follows:

Month	Made Tea	Yield per Acre
January	33,604	117
February	20,138	70
March	33,018	115
April	31,237	109
May	32,108	113
June	32,654	114
July	26,812	94
August	24,286	85
September	25,019	87
October	26,108	91
November	25,554	89
December	23,645	83
	334,183 lb	1,167 lb

Sale of Green Leaf

Green leaf was sold to Palmgarden Group factory and the poor prices realised for low-country teas was reflected in the prices paid to us, which to the end of December was 20.53 cts per lb.

With these prices, the estate could not naturally work at a profit, but the yield of 1,167 lb per acre obtained, offset what would otherwise have been a much greater loss.

Capital Expenditure

Quarters were built for the Head Teamaker, Assistant Teamaker and Factory KP. Eight sets of double unit quarters were also built to accommodate additional labour.

Factory

Work on the tea factory started in early January 1964 and was completed at the end of the year, and all arrangements to start manufacture on the 1st January 1965 were finalised. Messrs Walker, Sons & Co Ltd, did a very quick job in having the factory completed on schedule.

Cultivation

Pruning—142 acres were completed according to the programme.

Plucking—Rounds were maintained at 7-8 days. The average per plucker was 36 lb, compared with 41 lb the previous season.

Weeding—With the shortage of labour and prevalent wet weather, monthly weeding rounds could not be maintained, and to add to the difficulty in maintaining a strict monthly round, some contractors had forsaken their contracts to work for the building contractors.

Pests and Diseases—Some horse-hair blight was noticed in some fields. A survey on Shot-hole borer revealed 8–18% infestation with the higher level in fields nearing the end of the pruning cycle. No treatment was given as the infestation was not of a serious nature.

Supplying—100¼ acres were programmed in pruned fields but inadequate labour for this work has resulted in only 16 acres being supplied in Field No 2 at an average of 573 VP plants per acre.

Fertilizing—T 750 mixture was substituted in place of T 521. Frequencies of application being at intervals of three months, commencing two months after pruning, on a replacement basis of 12 lb Nitrogen for every 100 lb crop harvested. On this basis the tea received an average of 140.16 (N) 37.38 (P) 122.49 lb. (K)

One forking was done after pruning and broadcasting thereafter.

Shade and Green Manure Trees—Three rounds of lopping *Gliricidia* was done. Ring-barking of all the *Albizia* was completed during the year.

1964 *New Planting*—Planting commenced in May and the following VP plants of TRI Clone No 2023 were put out over an extent of 5¾ acres.

Month	No of Plants
May	2,340
June	5,019
July	18,915
August	1,200
	27,474
Resupplying done in September ..	1,469
„ October ..	1,959
	3,428

Cart Roads

The main Hidellena/Karapincha road is maintained by the estate. Parts of this road which were tarred were eroded by flood waters. This road was 12 feet under water in certain sections and the estate was completely isolated for two days in May.

	Men	Women	Children	Total
Working resident labour as at 31-12-64	236	198	11	445
Working non-resident labour as at 31-12-64	29	32	—	61
Total working labour	265	230	11	506
Non-working dependents	42	43	336	421
Total estate population excluding non-residents	271	237	332	840

Working labourers numbered 1.59 per cultivated acre. The number of workers per room is 2.50 and the number of souls per room is 4.72.

Visiting Agent

Mr J. W. Craig visited the estate on the 5th February, 9th July and 7th November, 1964.

General Remarks

We are once again grateful to the Manager of Palmgarden Group and Messrs George Steuart & Co Ltd, for their assistance and co-operation, which were available at all times.

METEOROLOGICAL OBSERVATIONS — 1964

ST COOMBS

Laboratory Gauges

Month	Temperature °F							Rainfall		Rainy Days		Sunshine	
	Mean Maximum	Average (25 years) Difference from	Mean Minimum	Difference from Average (25 years)	Adopted Mean	Mean on Grass	Mean Relative Humidity	Inches	Difference from Average (25 years)	Days	Difference from Average (25 years)	Hours	Difference from Average (25 years)
January	71.6	-2.5	54.2	-1.5	62.9	49.2	81	2.41	-1.19	7	-4	199.6	+6.90
February	75.9	-0.4	55.4	+0.8	65.6	52.1	67	4.11	+1.76	6	-2	176.0	-34.68
March	75.6	-2.1	55.8	+0.3	65.7	53.7	70	2.21	-2.33	8	-4	214.7	-18.31
April	75.9	-1.5	57.0	-0.8	66.4	55.6	66	4.40	-1.97	11	-5	222.6	+26.16
May	75.0	+2.6	59.2	-0.5	67.1	68.5	70	5.04	-6.24	11	-7	176.1	+12.10
June	73.3	+2.7	58.8	-1.6	66.0	58.2	57	4.65	-8.45	17	-9	101.8	+9.76
July	72.8	+2.6	58.8	-0.7	65.8	58.6	77	13.58	+1.84	22	-4	65.7	-39.49
August	73.3	+2.3	56.7	-2.5	65.0	55.2	75	7.89	-1.53	14	-11	134.6	+20.44
September	74.5	+2.3	58.4	+0.2	66.4	58.0	71	11.73	+3.36	18	-3	101.3	-39.02
October	74.3	+1.2	57.7	0	66.0	56.8	71	7.02	-2.67	19	-3	134.1	-15.26
November	74.8	+1.3	55.9	-1.2	65.3	54.7	73	8.67	+1.25	17	-2	176.5	+14.98
December	75.3	+1.8	54.4	-1.7	64.8	53.7	70	3.47	-1.75	10	-5	197.4	+28.17
	74.4	+0.85	56.8	-0.76	65.6	55.4	70.6	75.18	-17.92	160	-59	1900.4	-28.25
	Means							Total					