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A REVIEW OF AGRICULTURAL
RESEARCH IN SARAWAK,
BY
J. R. DUNSMORE .

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Agricultural research in Sarawak is commonly thought of as something of very recent origin: in the sense that such research should be the combined efforts of a team of scientists of various disciplines working together to solve the complex problems of farming this is true. But in a simpler form agricultural research began in Sarawak soon after the arrival of the first Rajah Brooke, for in the 1840s a Mr. Hentig was growing cinnamon, nutmeg, cloves, vegetables and "many other exotic plants" in Kuching.(1). Later Baroness Burdett Coutts was asked by the second Rajah to start an experimental farm at Lundu, First Division and an experimental garden at Kuop near Kuching both to demonstrate improved methods of farming and try new crops. The project, however, was a failure and was given up in 1872.(2). In 1875 Rajah Sir Charles Brooke attempted the introduction of Liberica coffee, cocoa and oil palm without significant success.(3). In more recent times a "Nursery for Imported Economic Plants" was opened at the 12th milestone Penrissen road, First Division (Semongok) in 1926, to provide a trial station for plants of economic importance introduced from abroad and to conduct experiments on pepper. In 1928 a Padi Field Officer (agronomist) was appointed and an Agricultural Chemist took charge of a laboratory of which it was said "nothing appears to have been spared in its equipment".(4), (the laboratory cost \$9,462.79!): it was however intended to serve all Government departments as an analytical laboratory. Both posts were vacated within a few years. Some investigational work continued at Semongok Central Agricultural Station. In 1937 a padi test station was opened in Kanowit, Third Division and selection work on Malayan varieties led to the recommendation of three varieties including Siam 29 for use in that district. In 1939 an area on the Igan below Sibul (Rantau Panjang) was cleared for use as the main wet padi station where the principal work was on the selection of 76 lines of the variety Acheh which had been grown the previous season in Lundu, First Division. In 1940 a new disease of pepper was reported from the Simanggang road.(5). It was a root disease, called foot-rot which was caused by a Phytophthora sp. but no further work was then done on it.

During the Japanese occupation of Sarawak all records and books at Semongok Central Agricultural Station were lost and the station was abandoned.(6). In March 1942 the Agricultural Training Centre was opened at the 34th milestone Serian road (Tarat), First Division for use as a demonstration centre of vegetable and food crop cultivation and a farm school was established but no research was done during this period.

The Department of Agriculture was re-established as a separate Department on 1st January 1947 when research work was started again but a lack of staff and facilities seriously limited what could be done. Varietal selection work on wet padi was continued at Rantau Panjang and some useful information on the rehabilitation of old pepper gardens was obtained at Tarat. Some work was done on other crops but "experimental work was simple and limited to little more than observation plots".(7). In 1949 a proposal that a Regional Agricultural Research Organisation for South East Asia be established was felt by the Sarawak Government to be too elaborate and costly for Sarawak needs and that it would be more suitable for the State to obtain the results of relevant research in Malaya and Singapore on a fee-paying basis.(7). Ten years later the possibility of establishing an agricultural research institute to serve the joint needs of the three Borneo territories was considered but the idea was rejected since the needs of the three States were not similar.(8).

At the end of 1952 a disease of pepper had destroyed many of the gardens, (including most of the pepper at Tarat) between Kuching and Serian and it was this that can be regarded as the starting point of the establishment of the present Research Branch. The extent and seriousness of the outbreak caused great alarm and a pathologist from Cambridge University, England visited Sarawak for three months in 1953 to make a preliminary study of the disease, (then called sudden death): he considered that the disease was of complex causation and recommended that a pathologist be appointed to investigate the matter. In 1955 two pathologists were appointed and later that year a laboratory was opened for them at Batu Lintang, Kuching. In 1956 approval was given for the establishment of a Soils and a Rice Research Division and the post of Soils Chemist and Rice Agronomist were filled for the first time in September 1957 and August 1958 respectively. Also in 1958 an F.A.O. Soil Scientist was assigned to Sarawak to establish a Soil Survey Division. Since then the number of research divisions has been increased by the addition of a Pepper Agronomist (1959), Entomologist (1960), Rice Botanist (1962), Oil Palm Agronomist, Analytical Chemist and Agricultural Economist (1964) and Soils Agronomist (1965). In 1959 the post of Assistant Director of Agriculture (Research) was created, so that today the establishment of research divisions under the Assistant Director of Agriculture (Research) is as follows:

- Agronomy - Cocoa
Pepper
Oil Palm
Rice
Soils
- Rice Botany
- Chemistry - Agricultural
Analytical

Economics

Entomology

Plant Pathology

Soil Survey (3).

Malaysian Research

Sarawak has for many years obtained much guidance and assistance from the Department of Agriculture, West Malaysia (formerly Malaya). Following the achievement of independence through Malaysia this co-operation was able to be put on a formal and permanent basis with the setting up of the Malaysian Sub-committee on Agricultural Research and the annual Malaysian Soil Scientists Conference. These together with informal meetings of specialist officers ensure that research work is not unnecessarily duplicated and that all workers are kept fully in touch with research throughout the Federation. For a small research branch such as the one in Sarawak this is of the greatest value.

Research Stations in Sarawak

Since May 1967 the headquarters of the Research Branch has been sited at the Agricultural Research Centre, Semongok twelve miles from Kuching. The main building offers excellent laboratory and office facilities and has been so constructed that another storey can be added if further space is required. The main buildings were financed by the First Malaysia Plan and the British Government contributed M\$850,000 towards the cost. The Centre is sited on the principal soil family of the State and results of field experiments there will thus be widely applicable.

Tarat experiment station is thirty-four miles from Kuching and the soils there represent families typical of many areas in the First Division. Much of the work on annual crops, fruit, pastures, pepper and cocoa has been done there.

The main wet padi station was opened at Paya Paloh near Muara Tuang, First Division in 1963. This area is typical of most of the wet padi areas of the State and replaced Paya Megok (27 milestone Serian road) where the value of experimental results was greatly affected by the atypical soils and frequent but unpredictable floods. Subsidiary padi stations exist in each of the other Divisions except the Fourth - Bijat-Stumbin, Second Division, Rantau Panjang, Third Division and Ukong, Fifth Division. Consideration is being given to opening a station in the Fourth Division in the Bekenu sub-district in one of the new Drainage and Irrigation Scheme areas: this would be particularly concerned with the question of extending double cropping in Sarawak.

There are two experiment stations mainly concerned with work on oil-palms. Danau on alluvial soils in the Fifth Division and Luak-Kebuloh on typical residual soils of the Fourth Division, where the greatest potential for the crop is thought to exist.

In addition many experiments are laid down on small holders land particularly on wet and dry padi, pepper and coconuts.

The Soil Survey division is based at the Soils Laboratory in Kuching which has the advantage over Semongok for the surveyors that it permits easy liaison with the Lands and Surveys and the Geological Survey Departments.

Some of the major achievements of the various research divisions are summarised below together with notes on current investigations. When considering the work described here it should be borne in mind that agriculture in Sarawak is pursued almost entirely on a small holder basis. The most important crop is padi which is grown both in swamps and, in the dry form, on the hill-side: it forms the basis of the subsistence livelihood of a large proportion of the indigenous people. Rubber is the most important of the export crops in terms of acreage planted but pepper, sago and coconuts are predominant among certain communities.

SOIL SURVEY

It is a truism that knowledge of the soils of a country is one of the fundamental requirements for any sound agricultural development planning and this was accepted at an early stage of the development of agricultural research in Sarawak.

Towards the end of 1958 a soil scientist of the United Nations Food and Agriculture Organisation was posted to the Department to advise on the setting up of a soil survey section. No soil surveyor was then serving in Sarawak but the expert made a start on the training of junior staff and carried out a number of surveys. He left in 1959 but in 1960 three soil surveyors were appointed and since then a strong soil survey division has been established. A tentative classification of the main Sarawak soils was made in 1962.(9), and in the same year a field classification of soils was prepared.(10). By 1965 sufficient information had been obtained to permit the production of a comprehensive classification of the State's soils at a great soil group and family level.(11). The classification is essentially a genetic one taking account of the origin and nature of the parent material and the degree of profile development. It is the intention eventually to adopt the American method of classification, (12, 13) and to facilitate this the

limits of many diagnostic horizons and other soil features used in defining the families have been chosen to agree with those of the American classification. During 1966 a reconnaissance soil survey map of the State at a scale of 1:250,000 was produced and it is hoped to print this at a scale of 1:500,000 for distribution in 1968. Complementary to the survey and classification are agronomic experiments carried out on the various soil families to compare and contrast the soils from the agricultural and economic point of view. The Soil Survey division has the following objectives:

- a) The systematic reconnaissance surveying of the whole country.
- b) assistance to Government in the selection of new areas for agricultural development.
- c) obtaining detailed information on areas selected for development.
- d) the study of the field and laboratory characteristics of soil series, their distribution in relation to each other, their genesis and agricultural potential.

To meet these it employs four types of survey

- a. Terrain classification: this was developed in 1962 for determining rapidly whether large areas of country (100 square miles or more) showed possibilities for agricultural development. The topography and vegetation are studied by means of air photograph interpretation. No soil data are obtained but it is possible to demarcate those areas unsuitable for agriculture by reason of topography and to infer unsuitable areas of deep peat, infertile hill and terrace soils and saline estuarine soils.
- b. Reconnaissance soil surveys: this involves a combination of air photograph interpretations and field work: large areas of about 100 - 500 square miles can be surveyed and mapped at a scale of 1:50,000 or 1:100,000 within a period of one to two months. The mapping units are mainly soil associations. Depending on the density of field observations and the accuracy of boundaries of mapping units these surveys are divided into detailed reconnaissance, reconnaissance and broad reconnaissance. By such surveys areas with agricultural potential can be picked out and routes for feeder roads selected.
- c. Semi-detailed soil surveys: these cover smaller areas usually less than 20 square miles and emphasis lies on field work with some air photograph interpretation. No land development or drainage and irrigation scheme is approved without such a survey having shown the proposed area to be suitable for the defined purpose. The soils map produced at a scale of 1 in 10-25,000 is suitable for physical planning.

d. Detailed soil surveys: in these all surveying is done in the field. Most mapping units are soil series and phases. The scale of the map produced will be not greater than 1:3,000. Such surveys are only used for experiment stations or similar work.

By the end of 1967 the following coverage had been completed.

Type of survey	Total area surveyed (at most detailed level)	
	<u>Square miles</u>	<u>Percentage of State</u>
Terrain classification	2,757	5.7
Reconnaissance	14,372	29.9
Semi-detailed	521	1.1
Detailed	<u>4.6</u>	<u>0.01</u>
Total	17,654.6	35.71

The soil survey has shown (11) that hill land covers 78% of the State: the major soil group in these areas is the Red-Yellow Podsolics. Other groups that are found, in decreasing order of area covered, are Grey White Podsolics, Lateritic, Podsol, and Brown Forest soils. All these groups contain skeletal variants and these are believed to account for much of the land of steep topography that is found in the interior areas.

Of the flood plains which cover 22% of Sarawak, 13% are mantled by Peat, 3% by Saline Gley and some 6% by Recent Alluvial and Gley soils. The Recent Alluvial and Gley soils are found mainly in narrow ribbons along the sides of rivers.

AGRONOMY and BOTANY

ANNUAL CROPS.

Rice

About 70% of the farming population of Sarawak are occupied mainly with the growing of padi. The crop is grown both as wet padi and dry padi. In terms of hulled rice local production is thought to be in the region of 60-65,000 tons per year and imports amount to 58-59,000 tons.

Dry padi. It is estimated that each year about 160,000 acres of land, much of it on the steep slopes (30°+) of the interior are felled and burnt for the planting of dry padi on a system of bush fallow. The yields are low, averaging perhaps 650 lb per acre and the system is prodigal in its demand for land and labour: with increasingly shorter fallow periods resulting in accelerating degradation of the soil and further reduction in yields the system is one which becomes increasingly less acceptable to the farmer and the State. It remains however an integral part of the way of life of many people and in spite of Governments efforts to assist the planter to change to a more rewarding form of agriculture the system may well continue for a generation. Efforts are therefore being made to ameliorate its effects so that the planter may obtain his family's requirements of rice from as small an area of land as possible with the least damage to the soil and with the minimum effort on his part. The results of trials so far may be summarised as follows:-

a. Fertiliser trials showed that economic increases in yield can be obtained by mixing a pelleted fertiliser containing 11% nitrogen and 48% phosphoric acid (21% P) with the seed just before sowing: the rate of application (2 lb per gallon volume (approximately 5.3 lb.) of seed) is approximately 10 lb per acre and costs \$2.40 per acre. Average increases in yield over similar non-fertilised areas have been estimated at 50%. Additional increases in yield have been shown to be possible in Fifth Division by top-dressing three weeks after sowing with 10 lb of nitrogen (22 lb of urea) per acre. Trials in the First Division on top-dressing gave variable results and on occasion yield depression was recorded possibly because of an increase in fungal leaf spotting.

In some areas there may be a response to potassium but further work on this is needed. There has so far been no indication of response to calcium and magnesium.

b. A collection of 97 hill padi varieties has been assembled including four from West Malaysia and nine "bulu" varieties from The Philippines. Twenty-seven of the highest yielding of these have been selected for trial in all Divisions of Sarawak and of these a number has shown a capability of producing 100 lb of clean dry grain per thousand hills when planted at a spacing of one foot by one foot in favourable conditions. This work shows promise not only of producing a suitable variety for better yields of traditionally planted areas but also for rotational cropping with other annuals and conceivably alternating with wet padi as a method of double-cropping.

c. While there are considerable variations hill padi tends to be sown at about 25-30 lb per acre dibbled in at a depth of three inches and at an irregular spacing of 15-18 inches. Reducing the seed rate and the depth of sowing appears to reduce yields because of bird damage shortly after sowing. Reducing the spacing to

one foot by one foot would probably increase yields though experiments on this gave varying results.

d. Pest damage in the field is not usually serious although a number of species are commonly found including stem-borers, [Tryporyza (= Schoenobius) incertulas, T. (= Scirpophaga) innotata, Chilo suppressalis, and Chilo (= Chiloatraea) polychrysa and Sesamia inferens], army-worm [Spodoptera mauritia], leaf folder [Cnaphalocrocis medinalis], green padi bug [Leptocorisa oratorius and other species], plant and leaf-hoppers [Nephotettix apicalis and other species. Tettigoniella spectra, Sogatella furcivera and Niloparvata lugens], mole crickets [Gryllotalpha africana] and rats. On occasion in restricted localities loss due to pests can be very serious and whilst satisfactory methods of control are possible for all pests except the stem-borers and these are available through a free pest control service there are considerable problems in affecting control due to the isolation and remoteness of many of the areas, the animistic beliefs of the planters and the difficulty of obtaining water for spraying.

Infestation of stored padi is not a serious problem in most areas although there is generally a small (2-3%) incidence of the grain weevil [Sitophilus zeamais] and the lesser grain borer [Rhizopertha dominica] in grain stored for 4-6 months. The Iban method of storage in a bark bin in the loft of the long-house makes the liability to serious damage by rats much greater.

e. Disease is not normally a serious problem although the leaf-spotting stages of Piricularia oryzae, Helminthosporium oryzae and Nigrospora oryzae are common particularly in dry periods. False smut, Ustilagoideae virens is also often found in very small degree. In the Serian district of First Division fungal leaf spotting is common and an experiment to test the effectiveness and economics of a number of chemical control measures was carried out over a number of seasons. These showed that over the period of the experiment increases in yield were obtained from the treatments but the problem is complex and further consideration of the matter is needed before conclusions are drawn.

f. It was thought possible that there might be a species of quick growing tree or shrub which, planted as a fallow crop, would be of greater benefit than natural fallow and allow the fallow period to be reduced. The plant would have to be easy to establish and need minimal maintenance and preferably have an economic product. Trials on a number of species have so far failed to produce any which appears capable of repressing the vigorous natural fallow.

g. An observation to study the effect of planting padi for one, two and three years successively on the yields of padi, the soil and the subsequent forest growth showed little variation in yield between the years but suggested that plots would be abandoned because of encroachment of weeds. The number of woody species declined markedly with a third planting though it was noted that regeneration of tree species by coppice shoots and seedlings even after only one planting was unexpectedly small.

h. Weeds are often so vigorous as to smother the padi. The present methods of hand weeding are both time-consuming and, usually, inadequate. The difficulty of obtaining water makes spraying difficult in many areas. When it is possible 2,4-D and MCPA can be used successfully when planting follows a long period of fallow. In areas where a young fallow is cleared many of the weed species may be resistant and spraying thus of little value.

Wet Padi. About 120,000 acres of wet padi are planted each year. The standards of cultivation are often very low and usually comprise slashing the fallow vegetation and burning it followed by minimal cultivation by hand. Small areas of the Fifth Division are prepared by trampling with buffaloes. There is no double-cropping. Many areas are cultivated only once in several years and very few have irrigation. Substantial increases in padi production could be achieved both by improving the standards of cultivation in existing areas and by increasing the area cultivated each year. Particular stress is laid on the need to increase padi production by the Prime Minister and Government and in accordance with this policy a feasibility study is expected to be undertaken in 1968 into the possibility of developing a large area of saline gley soils lying between the Santubong and Sarawak rivers in First Division. If this scheme materialises it will make the most substantial addition to rice production in the history of the State.

Experimental work over the last eight years has shown that the average yields from existing areas of wet padi cultivation could be more than doubled if the following points were followed.(14).

a. The same piece of land should be used each year. The reason for this not being more commonly practised is sometimes attributed to excessive weed growth but it is probably due to the fact that the padi is grown in areas of high rainfall and poor natural drainage in consequence there has been an increase of reducing conditions with resultant poor growth. This problem can be overcome by thorough drying out of the land in the off-season by construction of drains.

b. The construction of a controlled water system comprising drains and bunds and, where possible irrigation.

c. Improvements in nursery technique to ensure a large enough area [50 square yards per gallon (5.3 lb) of seed] and, in established areas, fertilising of nurseries with either a nitro-phosphatic fertiliser (Ammophos 11:48) at 2 lb per 50 square yards for a dry nursery and half this amount for a wet nursery or well rotted buffalo manure at 450 and 225 lb per 50 square yards, respectively.

d. Improvements in the standards of field cultivation. To achieve this by hand implements is possible but very laborious. A scheme to introduce buffaloes for cultivation work has been of only limited success. It has been proved on padi test stations and trials on small-holders land that small two-wheeled tractors are valuable when an area has been opened up for two to three years. Further work on the practicability and economics of their use in small-holders areas is necessary and it is hoped that this will start in 1968/69. Two seasons experiments cultivating the land with the chemical paraquat have shown great promise and wide scale field trials on small-holders land are planned for 1968/69 season. If this method were to prove satisfactory it would certainly be the fastest and easiest method to put across to planters.

e. As a general recommendation an application of 20 lb of nitrogen and 12 lb of phosphorus at planting time has been shown to give economic increases in yield. The need for potassium fertilising requires further trial: in some areas the addition of potassium has further increased yields: in others they have been depressed. Top-dressing (with 50 lb per acre of urea) three weeks after planting and at panicle initiation also increases yields.

f. The standards of weed control are generally low. Field trials have shown that, of the major weed species, 2,4-D and MCPA will control Commelina elegans, Jussiaea spp., Scirpus sp., Rhynchospora aurea, Limnocharis flava, Monochoria vaginalis and Fymbristylis miliacea. These herbicides are cheap and readily obtainable: however, their use must be followed by hand-weeding where Leersia hexandra, Isachne globosa and Ischaemum rugosum are present. Trials on other herbicides are currently in progress. Where weed infestation is not too heavy and the soil neither too deep nor hard the small Japanese rotary hoes have been shown to be useful.

g. The pests of wet padi are similar to those of hill padi (listed above) with the addition of case-worms [Nymphulas stagnalis, N. fluctuosalis]. Only the stem-borers present a problem in regard to control measures (see Entomology).

h. Investigations by the rice botany division have produced the following results

- (i) a collection of 309 local varieties was gathered from all areas of the State, and these have been classified and found to comprise 184 distinct non-glutinous varieties.
- (ii) the local varieties plus 140 imported varieties have been tested under both fertilised and unfertilised conditions to select varieties which are superior to the five currently recommended (Acheh 62, Lasak, Serendah Kuning and Siam 29 and, for areas subject to brackish water flooding, Kara. The 50 highest yielding varieties (39 local, 7 imported and 4 standard) have been selected for formal trial in four of the five Divisions. At present Acheh 62 appears to be the most consistent performer and have the widest adaptability: it also does well on peat. It may prove necessary to breed varieties specifically for the conditions in Sarawak as varieties that do well in other States of the Federation and elsewhere have had variable success in the State.
- (iii) trials are in progress on the selection of varieties that will tolerate (a) brackish water flooding (b) periodic drying out of the soil (c) peat soils so that they can be recommended for areas where these conditions exist.

Annual crops other than rice

One of the means whereby agricultural production could be considerably increased in a relatively short time would be by the expansion in production of a number of annual crops other than rice. The area used for this purpose at present is relatively small and it could be increased by making further use of the better drained gley and alluvial soils and the less steep slopes of the hill soils. In 1967 Sarawak imported \$730,893 worth of groundnuts, \$2,825,815 worth of maize and \$561,298 worth of soya-beans: much, if not all, of this could be produced in the State. The position with regard to research on these matters is stated briefly below.

Castor oil

With the new method of processing rubber into hevea crumb the demand for castor oil will increase and trials on this are planned to start in 1968.

Ground-nuts

No formal trials on different varieties have yet been carried out. Factorial fertiliser trials have been started but further experiments on both varieties and fertiliser requirements on the different soils are required.

Maize

Maize is commonly planted with the hill padi crop and harvested in December. Growth of the crop as a pure stand is found only on a small scale. Trials with the synthetic variety metro which started in 1966 have given the most encouraging results with yields of 3,800 lb per acre and higher of clean dry grain (this compares with 1,200 - 1,500 lb for varieties now grown). On alluvial soils fertiliser application supplying 65 lb nitrogen, and 34 lb phosphorus give economic responses: potassium is probably also required and there are indications that dolomite and some trace elements are beneficial but further work is needed on this.

Soya-bean

Variety and fertiliser trials on soya beans are still in progress. Indications point to the variety Sahah being a better yielder than those presently being planted: the local variety Nonok appears to have a better resistance to insect attack.

Sweet potatoes

In a variety trial at Tarat covering three crops and comparing twelve varieties the highest mean yields of fresh tubers per crop was obtained from the varieties Puteh (6.80 tons) and Telor Merah (5.93 tons). Three other varieties also gave satisfactory yields - En Tin (5.57 tons), Rojah Puteh (5.34 tons) and Hoey Fong (5.15 tons). All these varieties produced a mean yield of fresh tops in excess of 13 tons. Puteh is however of only medium palatability.

Three NPK factorial experiments harvested in 1967 suggested that increasing nitrogen application above 30 lb acre depresses tuber yields but increases the production of tops. 15 lb of phosphorus was sufficient on both residual and alluvial soils when phosphorus had been applied to previous crops. Potassic fertiliser may also be beneficial. Further work is planned on the fertilising of this crop.

Tapioca

Tapioca is widely planted in the growing hill padi crop to be harvested later from the subsequent fallow and is a valuable supplement to rice in the diet. It has also a commercial potential either for flour or for the production of chips for animal feed. In particular it might be suitable for planting on deep peat soils and work on this is now in progress.

A variety trial on five West Malaysian and five Sarawak tapioca varieties was repeated four times at Tarat. The crop was planted in a recent alluvial soil at a spacing of 3 feet by 3 feet and was not fertilised: it was lifted at 12 months. The highest yielding variety, Black Twig, gave a mean annual yield of 14.26 tons per acre. Five other varieties (Berat, Baloi, Kapok, Buloh and Sawah) gave a mean yield per acre of over 12 tons. This would be an economic yield for commercial production of chips. Further details are however needed on the starch content of the varieties: data presently available suggests that this varies notably between seasons. Additional work is also needed on the effect of different times of lifting and of fertilising.

Tobacco

Diseases have seriously affected work on tobacco in recent years. Frog's eye spot (Cercospora nicotianae) and bacterial wilt, (Pseudomonas solanacearum) pose a particular problem. The crop is grown on a small scale by small-holders at present and while returns are good the quality of the product is poor and the market limited. If satisfactory methods of producing a good leaf can be found it would be a very useful crop for off-season cropping of wet padi areas and elsewhere.

Vegetables

The major centres of population e.g. Kuching, Miri, are well supplied with vegetables produced in gardens in the surrounding areas. Some smaller centres e.g. Lundu, Limbang are chronically short. There are no technical hindrances to production here and the question of obtaining supplies is an extension problem rather than a research matter.

Trials on temperate vegetables at Bario, Fourth Division (3,000 feet plus) have shown that these will grow satisfactorily there. The problem however is in organising regular supplies from small-holders and also transport difficulties from this isolated area.

PERENNIAL CROPS

The major perennial crops grown in Sarawak today are rubber, pepper, coconuts and sago. The State has for a long time now depended largely on the Rubber Research Institute, Malaya for advice on all matters pertaining to rubber and only limited research on matters peculiar to Sarawak has been attempted: this is commented on briefly below. While the total area under sago is thought to be only in the region of 34,000 acres a large proportion of the Melanaus in the coastal regions of Third Division (Oya/Mukah/Balingian) have a sago-based economy. No agricultural research has yet been done on the crop but the need for it is accepted and plans are in preparation. Other crops which are either grown on a small scale or are under trial and could either play a larger role than they do at present or could perhaps be introduced to assist in diversification are bananas, citrus, cocoa, coffee, essential oil producing crops, manila hemp, oil palm, sugar-cane and tea and these together with coconuts and pepper will be discussed individually.

Bananas

Bananas are grown throughout the State on a small scale but they are only a significant economic crop in the Baram, Fourth Division and Trusan, Fifth Division, where they are produced for export to Brunei. Total exports for the State in 1967 amounted to \$38,000. There are obvious problems in organising a large-scale export trade in bananas where the crop is grown solely by small-holders; particularly in ensuring that the small-holders are always able to sell their crop and that a sufficient cargo is available when a ship is due. A further point to be considered is that two serious diseases of bananas are present in Sarawak - Panama disease, Fusarium oxysporum f. cubense and leaf spot, Sigatoka disease, Mycosphaerella musicola. While these are no problem at the present time they are likely to become so if bananas were planted on a large scale. In a variety trial at Tarat on a soil of alluvial/colluvial origin the highest yield was obtained from the variety Pisang Pisang: this however is of poor palatability. The varieties Embun, a Gros Michel type, and Keling, gave satisfactory yields and are popular on the local market and further work on this crop on different soil types should include these three varieties.

Citrus

Citrus is a minor crop in Sarawak at the present time and only plays a significant role in the economy of Chinese farmers in the Binatang district of Third Division. The mandarin and pomelo grow well in the State and there are some good clones available so that these could be grown on a large scale for home consumption and the domestic market. It is therefore proposed

to make a collection of the better clones during 1968 for selection trials at Tarat. An experiment has also been established at Semongok on West Malaysian smooth skinned and rough skinned limes to assess their production of oil of lime: arrangements have been made to obtain seed of West Indian lime in order to expand this work.

Cocoa

In 1950, 500 seedlings of selected West African Amelonado cocoa which had been produced at the West African Cocoa Research Institute, Tafo, Gold Coast (now Ghana) were received in Sarawak after being raised from seed in quarantine in Malaya. They were planted in observation plots at Tarat on a Recent Alluvial Soil. Over the period 1960-64 the plots produced the equivalent of over 1,000 lb of dried beans per acre per annum and it was decided in 1965 therefore to increase the work done on this crop and this programme now covers the following work:

a. the fertilising of Amelonado cocoa with the major elements (nitrogen, phosphorus, potassium, and magnesium) on different soil families. In 1965, a $3^3 \times 2$ factorial experiment was established on a Recent Alluvial soil under the shade of Gliricidia maculata and Adenanthera pavonina. By the end of 1967 there were no clear indications of increased growth in terms of girth measurements resulting from the use of fertilisers. A similar experiment is to be established at Semongok on a Red-Yellow Podsollic soil in 1968.

b. It is fortunate that the Department of Agriculture, Sabah made available to Sarawak planting material of a number of hybrid clones of Upper Amazon and Upper Amazon x Amelonado crosses. Trials on these including twelve hybrids and using West African Amelonado as a standard have been planted at Tarat and under coconuts in the Nonok peninsula. The experience elsewhere which showed that these hybrids were much superior in rate of growth to the Amelonado has been repeated. A further 13 hybrids have been received and will be planted at Semongok in 1968. This work is regarded as the most promising line to follow and great importance is placed on it. At the suggestion the Department of Agriculture in Sabah it has also been decided to establish a collection of a number of Upper Amazon clones from Pounds original Trinidad collection. These were imported into Sabah through Kew. They comprise five Scavina clones, one Iquitos clone, twenty-two Parinari clones and two 'Pound' clones (1944 expedition). They will be planted both at Tarat and Semongok.

c. With the present depressed world price of cocoa the experiments on the crop as a pure stand will have to be continued for several years before the economics of growing it in Sarawak can be assessed. A more

promising proposition for early implementation as an extension project is the under-planting of coconuts with cocoa on gley soils. Observations have suggested that a minimum shade of 50% is required for establishment of cocoa: tall coconuts planted on the gley soils at a spacing of 30 feet by 30 feet would give sufficient shade when 6-8 years old. Fertiliser and spacing trials on this method using both Amelonado and hybrid material were planted in the Nonok peninsula, First Division in 1966. Where the shade was sufficient, maintenance adequate and no brackish water present the growth was very satisfactory. In consequence towards the end of 1967 nurseries were established in 60 holdings throughout the Beliong-Nonok area with the aim of under planting 100 acres of coconuts with cocoa for extended field trial in 1968. The cocoa will be planted in double-rows at 10 feet by 10 feet within the coconut rows at approximately 30 feet by 30 feet. For these cooperative trials all materials including fertiliser and fermentaries will be supplied free by the Research Branch but the small-holder will work the plots without wages.

d. Small observation plots have also been established with cocoa under old seedling rubber. These comprise both plots with a single row of cocoa between the rows of rubber where the object is to see if the cocoa can supplement the income from the rubber and a full stand of cocoa where the intention is to study the feasibility of establishing the cocoa under rubber with a view to replacing the rubber with cocoa with no intermediate loss of income to the farmer. Initial growth of the cocoa, has been very satisfactory but none of it is yet in bearing.

Coconuts

The introduction of the Coconut Planting Scheme in 1959 which offered free materials and a small cash subsidy to farmers resulted in an increase in the area under coconuts from 45,000 acres in 1960 to 88,000 acres at the end of 1967. The crop is grown mainly on marine sands and drained saline gleys and gley soils: on the latter good drainage is essential. Fertiliser observations on a number of soil families were started in 1965 and present indications are that responses are obtained on all soil types particularly the sands. Nitrogen and phosphorus applied without potassium appear to have a depressing effect.

It is hoped to carry out trials on grazing areas of coconuts grown on marine sands. An increased income from coconut holdings established on clay soils could be obtained by under-planting Robusta coffee and fertiliser experiments on this system are planned for establishment in the second half of 1968. Trials on under-planting with cocoa are in progress (see Cocoa).

Coffee

In 1967, Sarawak imported \$1,460,000 worth of coffee beans: much of this could be produced economically in the State. Both Liberica and Robusta coffee grow well on the alluvial and residual soils. Experiments on both varieties of coffee are in progress at Semongok to ascertain the economic fertilising programme required for a common upland soil: from the start it was obvious that nitrogen and phosphorus were essential. With Liberica coffee in terms of girth measurement on this Red-Yellow Podsollic soil: an application of 24 lb of nitrogen and 15 lb of phosphorus per acre in the third year (following 1/3 rd and 2/3 rds this amount in the first and second year respectively) was the best. In terms of early bearing and yield however, there are suggestions that higher nitrogen and phosphorus together with potassium are beneficial.

An observation has also been planted at Semongok to test three Arabica x Robusta hybrids received from India. They are thought to be adapted to lowland conditions and yet retain some of the quality of the Arabica parent. Arabica coffee (Strain S.795 from Mysore, India) failed to do well at Tarat but will be tried at Bario, Fourth Division (3,000 feet plus).

Essential oils

Small clumps of some of the essential oil producing plants such as lemon grass, Cymbopogon citratus, and citronella grass, C. nardus are often found growing well near houses. These, together with patchouli, Pogostemon cablin, vetiver Vetiveria zizanoides and kenanga Cananga odoratum are being planted on the peat soils of Stapok and the residual soils at Semongok to see if they have a commercial potential. The yield of oil obtained from random samples of lemon grass, citronella grass, vetiver and patchouli compared reasonably well with figures quoted in the literature.

A still is being set up in Semongok.

Manila hemp

Manila hemp has the advantage that with little instruction the small-holder can produce a first quality product. Variety trials planted at Tarat on a Recent Alluvial soil and at Semongok on a Red-Yellow Podsollic soil have grown satisfactorily; the variety Tangongon appears to be the best, at Tarat producing 54,780 lb of stems with a 2.14% fibre content in the first full year of bearing. The diseases, Marasmius stenophyllus, Deightoniella torulosa and Cordana musae are commonly present.

Oil Palm

An attempt in the 1930s to establish an oil palm estate in Kanowit, Third Division, using Dura material failed because of poor fruit setting. Similar material planted in small groups in many other parts of the State at this time can however still be found growing and fruiting satisfactorily. Research on this crop was therefore thought to be warranted and a soil survey in 1960 (15) located a suitable area of land on alluvial soil on the true left bank of the Limbang river, Fifth Division between Ukong and Danau. In 1961 a fertiliser observation on Dura x Tenera material was planted and in 1962 a factorial fertiliser trial on Dura x Pisifera material was established. In spite of severe floods in 1963 the growth and yield of the palms has been excellent and funds have therefore been approved for the opening of a 600 acre small-holders scheme in the area in 1968.

During the course of the reconnaissance soil survey of the State a substantial area of land was found in 1961 lying in the Bekenu-Niah-Suai area of Fourth Division which was unencumbered by any land rights and had suitable soil and topography for oil palm development on a considerable scale.(16). A new station (Luak-Kebuloh) to be used principally for oil palm experimental works was selected in 1963 and work began on clearing the jungle, a task which was complicated by the inaccessibility of the area at that time: (today the main Miri-Bekenu road runs alongside the station). The first oil palm experiment was planted in 1965 and by 1968 the following experiments had been planted using D x P palms.

- a. Factorial fertiliser experiments (NPK Mg) both on Brown Forest/Recent Alluvial soils and Red-Yellow Podsollic soils.
- b. Cover crops experiment comparing creeping leguminous cover, bush legume cover, natural cover and economic crops.
- c. Spacing trial comparing 24, 30 and 36 feet planting both on the square and triangle.

Growth of the palms has been excellent and the first commercial venture in the area began in March 1968 when the Commonwealth Development Corporation of the United Kingdom began work on opening up a 5,000 acre estate. Observational trials on six different soil series or phases planted early in 1967 showed after one year that growth on the Pendam series (saline gley) was particularly good.

If the plant planned for use at Danau for 600 acres is successful similar schemes would be possible in all Divisions. Development of large units (3-5,000 acres) is expected to occur in Fourth Division near to the Miri-Bintulu road.

Pepper

Pepper is one of the major agricultural export crops of Sarawak. The 1967 export of 10,777 tons of white pepper and 8.724 tons of black pepper earned M\$35,468,890. The crop is entirely grown by small-holders and the average size of garden is only a little over 0.5 acre. Until recently, it was grown almost exclusively by Chinese but there is now a significant and increasing area cultivated by Dayaks.

The pepper industry was almost completely destroyed during the Japanese occupation. At the end of the war with the high world price of pepper, considerable replanting took place but the traditional method of cultivation whereby burnt earth was produced as fertiliser from an area perhaps three times the size of the holding was no longer possible. The land available for planting was mainly on exhausted soil often covered with lallang, Imperata cylindrica. Organic manures of various forms with which the farmer had no experience were liberally applied. By the middle of the 1950s it was apparent that the new methods of cultivation were resulting in lower yields, biennial yielding and a reduction in the economic life of vines. This was aggravated by the outbreak of disease in 1953, which killed off large numbers of the gardens (see Pathology). The need for both agronomic and pathological studies was obvious and an agronomist to work on pepper was appointed in 1959. The world market for pepper was considered to be limited and increased production thought to result in a fall in price: investigation was therefore aimed at both ensuring sustained annual yields over a reasonable period and reducing to a minimum the cost of producing pepper. A comprehensive programme was designed to ascertain the best fertilising programme: this covered both a comparison of organic and inorganic fertilisers and major and trace elements. Other trials tested various cultural methods e.g. holing, mounding, cover crops and mulching.(11). Results obtained by 1963 enabled a tentative recommendation to be made for the fertilising of pepper using an inorganic compound or mixture of the following composition - 12% N; 12% P₂O₅; 17% K₂O; 2% MgO and trace elements. The programme of applications recommended for this was much cheaper than many methods of fertilising then being practiced and the consensus of opinion by those who used it was that it was good. By the end of the 1967 harvest a vast amount of further data was available and using this the recommended fertiliser programme is being reviewed to see if further improvements particularly in terms of

reduced costs can be made. The need for magnesium and trace elements including manganese, boron and copper has been shown in a number of experiments.

An experiment at Tarat planted in December 1960 to test a number of cultural treatments has shown that no benefit is obtained from preparing a planting hole (two foot cubed) as compared with none: suggestive increases were obtained from mounding up the vines. Mulching with a layer of cut grass (Imperata cylindrica) at the beginning of the dry season has had a beneficial effect on yields.

A variety trial comparing the Indian varieties Cheriakaniakadan, Balancotta, Kaluvally, Uthirancotta, the Indonesian varieties Bangka, Balantung and Djambi and the Sarawak variety Kuching was planted in 1960. The experiment later had to be terminated due to attack by foot rot (Phytophthora palmivora). It did however indicate the following:-

1. Bangka and Kuching are probably the same variety. They gave consistently high yields which rose from the first to the fourth year of production. They appear to be largely resistant to attack by the weevil Lophobaris piperis but are highly susceptible to foot rot.
2. Djambi and Belantung gave low yields in the first three years of harvest but in the fourth year equalled Kuching and Bangka. They showed a field resistance to both foot rot and the borer.
3. The Indian varieties while yielding less than the Indonesian and Sarawak varieties and also proving susceptible to borer did show a field resistance to foot rot.

The desirability of allying the high yield of the Kuching variety with the disease resistance of the exotic varieties was obvious. Earlier work on the grafting of pepper had not proved to be successful and therefore work was concentrated on hybridisation. A satisfactory technique was evolved and this work is still in progress. A further attempt at grafting was also made and the assistance of East Malling station in England was obtained. Successful grafts have now been achieved in England and Sarawak and bud-grafted material is now under field trial in Sarawak.

A preliminary observation had suggested that labour costs could be reduced and yields per acre of pepper much increased by planting pepper in six-foot high 'hedges' as is the practice with grape-vines. The yields of a formal experiment on this have however shown that in the first two seasons at least the yields per acre from pepper planted traditionally on 12 foot poles at 8 feet by 6 feet were higher than hedge-planted

pepper. Some method of reducing the labour required for pruning and harvesting would though be of great help in reducing costs of production.

Further work is also needed on the correct fertilising of pepper particularly studying the role of trace elements. The use of foliar analysis for the purpose is currently under study.

Pineapples

Pineapples are found in small scattered plantings in the hill padi areas. On a slightly larger scale they are grown on peat soils for the local fresh fruit market: the main variety grown is the Sarawak (Smooth Cayenne) and some Mauritius. The Malayan pineapple canning industry is based on peat soils, (18) and one can reasonably expect that the similar peat in Sarawak could be exploited in the same way. Sales would have to be made abroad through the Malayan Pineapple Board and the variety used should be the Malayan canning variety, the Singapore Spanish. A fertiliser experiment on this will be planted at Stapok at the end of 1968 using planting material (basal slips) from Johore.

Rubber

The State has been fortunate to be able to call upon the advice of the Rubber Research Institute, Malaya even before Independence. Research work on this crop has therefore been very limited. Experiments on fertilising seedling nurseries were carried out and enabled a new fertiliser programme to be recommended which substantially cut costs.

Growth measurements of seedling rubber grown on rubber planting schemes have shown that the residual (upland) red-yellow podsollic soils appear to constitute the best rubber growing soils in the State and are superior to the gley and the recent alluvial soils; although they are inherently less fertile their superior natural drainage permits better growth and yield.

Sugar-cane

Sugar-cane is not considered to be an economic proposition for large-scale cultivation in Sarawak because of the lack of a distinct dry season, the absence of a sufficient area of suitable land and the current low price of sugar on the world free market. It might however be suitable for growing as a small-holders crop as a cottage industry being processed by means of the Indian 'open pan system'. With this object in view observation trials on thirteen local varieties, twelve varieties received from the Bureau of Sugar Experiment Stations, Queensland, Australia and nine

varieties from the Sugar-cane Breeding Institute, Coimbatore, India have been planted on deep peat at Stapok and on mineral soils at Tarat.

Tea

It was thought that the climate and soils of Sarawak was suited to tea and to test this hypothesis a clonal trial on five West Malaysian lowland clones. (Bukit Cheeding 196, 223 and 600 and Ampar Tenang 30 and 53) was planted at Semongok in October 1966: a fertiliser trial (using Ampar Tenang 53) was planted in March 1967. The growth of the tea has been excellent and wider-scale trials are planned.

ANIMAL HUSBANDRY

Among the rural population of Sarawak there is little tradition of animal husbandry and in many communities livestock still plays a negligible role in the economy. This is unfortunate because the addition of animal protein to the diet would be of great advantage. It is, however probably a consequence of the traditional methods of agriculture (shifting cultivation), the topography and the climate. Increases in the production of pork and poultry products using intensive methods can be achieved fairly readily using methods of almost universal applicability and this process is currently in progress in Sarawak, most notably with pigs the imports of which fell from 16,585 in 1961 to 6,735 in 1966. Imported livestock feed however is expensive and for this reason work has been done on the evaluation of cheaper feeds of predominantly local production. A simple observation trial on pig grower feed showed that with a ration in which sago flour comprised 46% the mean feed conversion ratio was 5.67 as against 4.48 for a standard proprietary brand and that the quality of carcass produced was if anything better. The serious defect of the local ration was its lack of palatability with a consequent greatly reduced daily food intake. This work needs to be taken further but it would require greater facilities than are available at present. The problem of finding an adequate source of locally available protein of uniform quality has also not been resolved.

A formal experiment on feeding laying poultry based on work done in Papua and New Guinea (19) was carried out at Tarat and Semongok in 1966/67. The results are now being analysed but it would appear that it should be possible to produce a ration composed

predominantly of locally grown ingredients which would cost less in terms of pounds of feed per dozen eggs than the currently used proprietary ration. Adjustments to the ration will however be needed to improve the quality of eggs produced and it is hoped to do this in 1968.

The total number of buffaloes and cattle in the State was estimated to be 16,000 head in 1967; imports of bovines for slaughter was in the region of 1,600 head. Under the Development Plan it is intended to increase the local population of bovines and in this connection work done at Tarat on fodder grasses and pastures is of considerable relevance. This may be briefly summarised as follows:-

- a. Of the three fodder grasses, Guinea, (Panicum maximum), Guatemala, (Tripsacum laxum) and Napier, (Pennisetum purpureum), Napier grass gave the highest yields per acre and is acceptable to stock when chaffed. It would now be recommended for planting at 2 feet by 2.5 feet where weeding will be done by herbicide and hand and 6 feet by 1.5 feet where weeding is by small machine.
- b. Guinea grass gave the highest percentage protein, 16% (but not the highest yield of protein per acre).
- c. Stall fed Sindhi x Kelantan cattle consumed 70 lb of fresh grass per adult equivalent (650 lb) per day. Under the conditions at Tarat Guatemala grass had a carrying capacity of 2.66 adult equivalents per acre; it could thus be expected that Napier grass could carry 3 a.e.p.a.
- d. Of the pasture grasses under trial Pangola grass, Digitaria decumbens has been notably successful. An 8-acre pasture has been established and divided into four two-acre paddocks with a central shed. The paddocks are grazed in rotation and carry 2 adult equivalents per acre and allow 0.6 lb live weight gain per head per day without additional feed other than mineral salts. Each paddock is grazed for approximately two weeks in two months. After grazing, weed species are killed by spot spraying with paraquat and the area is fertilised: the annual rate is 4 cwt. per acre of a mixture of 5 parts of urea, 5 parts double superphosphate, one part muriate of potash and 1% fritted trace elements. The soil at Tarat is of alluvial/colluvial origin: the trial is being repeated on the Red-Yellow Podsollic soils of Semongok.
- e. Brachiaria brizantha, Ischaemum rugosum and, for poorly drained soils, Brachiaria mutica are also showing promise.

f. Two species which are often found naturally colonising areas in Sarawak, Ischaemum aristatum and Paspalum conjugatum did not stand up well to grazing. (The Ischaemum was seriously affected by the smut, Sorosporium flagellatum).

g. Centrosema pubescens is a promising legume to establish with the grasses.

Trials on these and other species are in progress at Semongok.

CHEMISTRY

The establishment of the chemistry division includes the posts of Agricultural Chemist and Analytical Chemist: for only a brief period however have both posts been filled simultaneously. In spite of this the division has been able to provide an analytical service. (20), for other specialist officers of the Department of Agriculture and also to other Government Departments and private companies. It has also been able to carry out research projects often in association with other officers. One of these involved the study of the changes which occurred when the Red-Yellow Podsollic soil at Semongok was fertilised and planted to rice and maize. (21). A chemical survey of export pepper showed that Sarawak pepper properly cleaned and dried could reach the standards required by the United States, which are the most stringent of all importing countries. A study over a period of three years of the quality of irrigation water at the main padi experiment station (Paya Paloh), has yielded results which are not only of relevance to the station but also indicative of the suitability of river water in many of the wet padi growing areas where salinity in the off-season is a problem in the extension of irrigation facilities. Current work includes a full study of variation in leaf nutrient composition with position and time of sampling on the pepper vine with the object of developing a technique of foliar analysis to assess fertiliser requirements and the setting up of a still in connection with the work on essential oil producing plants.

ECONOMICS

The post of agricultural economist has only been filled for the period 30 April 1964 to 9th September 1966. The work of this division is of particular importance at this time of great endeavour in the field of rural development and it is hoped to obtain

the services of a contract officer to cover the period until a local officer now studying in England returns.

The major accomplishment of the division to date has been a comprehensive study on the production and marketing of Sarawak pepper.(22). Production data was collected using a survey method with complete enumeration. A study of the marketing arrangements for pepper was also made. As a consequence of this report active consideration is now being given to the introduction of a compulsory marketing and grading scheme.

Other work of the division includes

- a. the preparation of a map showing most of the sago growing areas which will be basic to the proposed socio-economic survey of the areas where the economy is based on sago.
- b. the compilation of records and accounts for rubber small-holdings and poultry keepers.
- c. the preparation of an annual digest of agricultural statistics.
- d. the preparation of forecasts of the pepper crop for local and overseas information.
- e. a preliminary crop cutting survey of padi was carried out by the division in 1966 in Bau district, First Division. A State-wide survey was organised for the 1967/68 crop as a joint project by the Departments of Agriculture and Statistics.

ENTOMOLOGY

In 1960, an entomologist from the Commonwealth Institute of Entomology, London was seconded to Sarawak for two years to establish an entomology division within the Department of Agriculture: his work covered the setting up of a laboratory, the training of junior staff and the start of a reference collection of insects. In 1962, the pool entomologist handed over to a departmental entomologist.

Preliminary surveys indicated that the most important entomological problems were concerned with the pests of padi, (23) particularly stem-borers and to a lesser extent with pests of pepper and it was therefore on these that work was concentrated, particularly on the stem-borers of padi.

Of the five borers found in Sarawak Tryporyza incertulas is usually the commonest in wet padi planted in September/October: in padi planted later Chilo suppressalis is predominant. Sesamia inferens is also common in wet padi while T. innotata is the commonest species in hill padi; Chilo (Chilotraea) polychrysa is usually of minor importance. Before sound recommendations for control of these pests could be made it was essential to study their life history, ecology, natural mortality, alternate hosts, and the extent of the damage they cause. These matters have been studied exhaustively since 1962 and it has been shown that:-

- a. Difficulty arises in distinguishing between the immature stages of borers and work therefore had to be done on setal patterns and general larval and pupal morphology.(24). It did not however prove possible to differentiate between the early larval instars of T. incertulas and T. innotata.
- b. Borer incidence is generally low until the pre-flowering stage (February/March) when there is a considerable increase.
- c. The distribution of borer larvae was non-random and numbers were greatest in hills with most tillers.
- d. Light trap data was found to give inaccurate assessment of the species composition and did not establish true population trends as revealed by actual examination of the crop.
- e. There is considerable mortality in the pre-adult stages as a result of the activities of egg parasites and predators: this is an important consideration when the question of chemical control is raised.
- f. Estimates of grain loss are difficult to make but probably do not exceed 5-10% on the average: control measures would therefore only be economic in the higher yielding areas.
- g. Foliar applications of insecticides are of only limited effectiveness under the high rainfall conditions in Sarawak. Current trials are therefore testing the effectiveness of applying gamma B.H.C. to the irrigation water.
- h. Varieties differ in their susceptibility to attack by borers and this aspect of the question is presently being investigated. Of the varieties currently recommended Serendah Kuning and Siam 29 are among the more resistant.
- i. Chemical control trials have resulted in greater increase in yield than could be attributed solely to the control of stem-borers and work on the economic importance of such other pests as the rice coreids Leptocorisa spp. is in progress.(25).

In 1967, outbreaks of the army worm Spodoptera mauritia acronyctoides occurred scattered over an area of 6,000 square miles and it was estimated that 25,000 acres of rice (wet and dry) was affected. The opportunity was taken to make observations on the bionomics of the pest.(26). The outbreak appeared to be due to a prolonged period of unusually dry weather followed by sudden rainfall. In wet rice it is considered that there will be a natural decline in the number of army worms after the first generation. However yield losses will be reduced if an insecticide (e.g. D.D.T.) is applied followed by a nitrogenous top-dressing. Insecticidal control is necessary in hill padi because of the lack of compensatory growth under the conditions in which it is grown.

The routine spraying of pepper carried out by Chinese pepper gardeners is generally effective in controlling pests: indeed the spraying, often of eight application per season is probably excessive. The two major pests are the tingid bug Diconocoris hewitti and the coreid bug Dasynus piperis. At the turn of the year 1964/65 there was a severe outbreak of the former which afforded the opportunity to study the ecology of the pest.(27). It has been shown that complete control can be obtained by spraying with either B.H.C. (1.25 lb a.i. per acre) or carbaryl (1 lb a.i. per acre).

Work on pests of coconuts, citrus, coffee, maize and vegetables has been confined to simple observations on methods of control.

It is realised that with the clearing of primary jungle for land development and the diversification of agriculture, new pest problems may well arise and work is now in progress on a survey of the insects in lowland primary rainforest to discover the ecology of the commoner insect defoliators and borers.

PATHOLOGY

Serious concern was aroused in 1952 when a root disease attacked pepper and threatened to destroy the entire industry.(28). It was first called sudden death but later the name was changed to foot rot. Following a report by a specialist in 1953 (29) the services of two pathologists were obtained in 1955 and towards the end of that year a laboratory was opened. Investigation into this disease has continued to be the main pre-occupation of the Pathology division and much information has been obtained on the symptoms, aetiology, mode of spread and possible preventive measures. In 1956 the pathogen was shown to be a species of Phytophthora (30)

and it was evident that the disease was present in all pepper-growing areas of the State. It was noted that by the time that the symptoms of the disease were recognisable it was too late to save the vine. In 1961 oospores of the species were discovered in a growth in pure culture on oatmeal agar, but the significance of these in the spread of the disease is not yet known.(31). While soil infection continues to be the principal method of spread, root contact, rain splash, transmission by snails (32, 33) and aerial infection are also possible.(34). It was observed that in disease-free areas outbreaks of foot rot did not occur until the crop was over eighteen months old: it is now known that this is due to disease escape. No alternate hosts have yet been found nor has a resistant strain of the Kuching variety been discovered. It has been shown that the incidence of the disease can be reduced if

- a. Pepper gardens are well drained and are fenced off.
- b. Bordeaux mixture is applied as a foliar spray at fortnightly intervals during the north-east monsoon season.
- c. Sloping land is terraced.
- d. Inter-mound areas are put down to cover crop, trials of which are now under progress.
- e. Poison baits are put down in areas where the giant African snail (Achatina fulica) is found.
- f. The lower branches of the vines are pruned off to a height of one foot.

A number of overseas varieties have shown a field resistance to foot rot and are being used in grafting and hybridisation trials (see Pepper).

The other pathogenic diseases of pepper including pink disease (Corticium salmonicolor), thread blight, (Marasmiellus scandens) and white root disease (Fomes lignosus), can be controlled without difficulty. A suspected stunt virus is occasionally observed.(35). Two physiological diseases found in the Miri-Bakam area of Fourth Division are attributed respectively to water-logging (slow decline) and scorching by fertilisers incorrectly applied across the underground stem (wet rot).

A wilt of coconuts which had first been reported in 1957 and was considered to be potentially serious was shown on investigation to be initially the result of lightning strike. Some degree of

correlation between the distribution of the wilt and the occurrence of thunderstorms was shown. The incidence of the wilt was found to be slight and scattered but universal.(36).

A disease on dwarf coconuts at Tarat station, fruit rot (Phytophthora palmivora) previously unrecorded in Malaysia, was found to be controlled by spraying fortnightly in the monsoon season and monthly in the drier season with Bordeaux mixture (10:15:100).

In 1965 Sarawak participated for the first time in the International Uniform (Rice) Blast Nurseries programme organised by F.A.O. and the International Rice Committee and the work has continued since then. The standard method of assessment is also used to check varieties in the selection programme.

Trials on the padi straw mushroom (Volvaria esculenta), were successful. It was shown that shade was an inhibiting factor to production and that polythene sheeting reduced yields. An observation on Lentus elodes at Bario, Fourth Division (3,000 ft. +) was a failure due to the high temperatures.

April 1968.

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