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## CONTENTS

# RED TIDE AND PARALYTIC SHELLFISH POISONING IN PAPUA NEW GUINEA

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## ABSTRACT

*Reports of red tides and shellfish poisonings in Papua New Guinea waters are described and discussed. Descriptions are also given of various phenomena resembling red tides.*

## INTRODUCTION

Paralytic shellfish poisoning is caused specifically by toxins from certain dinoflagellates which are normally present in very low concentration in the sea. Occasionally, in response to a favourable change in their environment, they undergo a rapid population increase, when their numbers may attain several million per litre, forming visible patches on the surface, or "red tides". Humans are poisoned by eating bivalve shellfish which have been exposed to a red tide, and have thus ingested large numbers of dinoflagellates and stored their toxin. The symptoms are quite characteristic.

Until recently, the only published record of paralytic shellfish poisoning in the southern tropical Pacific area was a single fatal case at Manus Island, in 1962. However, in April, 1972, there were three deaths, all indigenous children, at Walai, Central District of Papua New Guinea, from paralytic shellfish poisoning. During the period March to July, 1972, a total of 28 non-fatal cases was admitted to Port Moresby General Hospital from coastal villages between Walai and Port Moresby.

Extensive patches of red tide were seen during aerial surveys of the affected areas shortly after the Walai fatalities. Further, red tides had been observed in Port Moresby Harbour almost continuously from December, 1971, to May, 1972.

The villages affected had no history of paralytic shellfish poisoning and it is tempting to conclude that the event was an isolated phenomenon. However, there is evidence that red tides are probably common in Papua New Guinea waters and that paralytic shellfish poisonings are more frequent than is generally recognised.

Below is an annotated chronological list of reports indicative of red tide and/or shellfish poisonings in Papua New Guinea waters, together with whatever evidence is available. Most of the reports are contained in Department of Agriculture, Stock and Fisheries (DASF) files. They have been followed up where possible, to determine species of shellfish and gather other relevant background information.

## OBSERVATIONS

| Date. | Report. | Source. |
|---|---|---|
| May, 1956. | Over a period of a few days, 97 persons were affected and one elderly man died as a result of paralytic shellfish poisoning after eating bivalves (*Anadara maculosa*) from the large lagoon south of Losuia in the Trobriand Islands. | A. M. Rapson. Paper for the South Pacific Commission Conference, 1968. |
| May, June, 1956. | Numerous accounts of dead turtles, fish and porpoises washed ashore in the Milne Bay area (including Trobriands) with deaths "extending westwards". Dead fish and turtles were reported near Talasea, West New Britain at about this time also. | A. M. Rapson. (Ibid). |

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Observations.—*continued*

| Date. | Report. | Source. |
|---|---|---|
| January-May 1961. | Red tides were visible around Talasea, New Britain, the sea was red by day and phosphorescent by night. Many fish and turtles were found dead along the shore. | Health Officer, Talasea, in DASF Files. |
| March, 1961. | Three non-fatal cases of paralytic shellfish poisoning were treated at Talasea at this time—an adult male from Talasea and, on another occasion, two boys, aged 3 and 11, from Pangalu village, 5 kilometres north of Talasea. The adult was poisoned by the Brachiopod, *Lingula*. | Ibid. Brachiopod species identified by Prof. Chuang from samples collected by the author following discussion with the man poisoned. |
| 20th April, 1961. | A girl aged 2½, of Garili village, 10 kilometres south of Talasea, died 3 hours after eating raw oysters (*Saccostrea cucullata*). Her mother, who also ate the oysters, died an hour later. A third death, that of a woman, occurred about a week afterwards in the same village. | DASF Files. Oysters identified by Mrs Whybrow, British Museum. |
| May, 1961. | Red tide was present along the West New Britain coast, being worst in Reibeck Bay. Intermittent patches and streaks extended almost as far north as Rabaul. | A. H. Banner, in DASF Files. |
| 23rd May, 1962. | A man at the Lombrum Naval Base, Manus Island, died as the result of eating three or four cooked shellfish (*Spondylus ducalis* Roding) from a lighter which had been placed in dry dock. Symptoms were of paralytic shellfish poisoning. A second man who removed the stomach portion and recooked the meat before eating it, was unaffected. Six days prior, three out of five persons eating cooked *S. ducalis* from the same source exhibited mild symptoms of paralytic shellfish poisoning. | Acting District Commissioner, Manus, and DASF Files. Species identified by Australian Museum. Brief mention of the fatality was made by Halstead (1965). |
| 28th May, 1963. | Red tide had been present in the Talasea (New Britain) area over the previous few weeks. Some villagers who were collecting shellfish in this area became acutely and seriously ill, presumably from eating the shellfish. However, a further five people after bathing in red tide contaminated seawater, were treated for the following symptoms; (1) sensitivity of the skin as sunburn, and (2) formation of hive-like lumps and/or weals on the skin. One woman had died from respiratory failure 2 hours after eating food prepared in water contaminated by red tide. (See March, 1973, report from West New Britain.) | DASF Files |
| 29th June, 1963. | Red tide was still present in patches off the coast near Talasea. Some dead turtles and fish had been washed up. | Ibid. |
| 5th July, 1963. | Except for a few small patches, red tide had disappeared by this time from the Talasea area. | Ibid. |
| September-November, 1969. | Red tide was seen during this period in Bostrem Bay near Madang. The causative organism was the dinoflagellate *Gonyaulax polygramma*. | Observations by Dr B. Sweeney, Alpha-Helix expedition (unpublished). |
| 16th November, 1970. | A patch of dying juvenile skipjack tuna (*Katsuwonus pelamis*) over half a kilometre long was reported in an area of red coloured water outside Bootless Bay, near Port Moresby. It is possible that the fish were *Rastrelliger kanagurta* and their behaviour was surface feeding. However, the presence of red water is significant. | DASF Files. *Rastrelliger* information from Dr R. Kearney. |
| April, 1971 | A fatal paralytic shellfish poisoning of an indigenous woman at Kiriwina, Trobriand Islands, by the cockle *Anadara maculosa*, locally called "tumeri". A further 17 affected villagers reported to the hospital at the time. Tumeri is known by the Trobriand Islanders to be | From Losuia hospital records. Shellfish identified following discussion with villagers. |

**Observations.—*continued***

| Date. | Report. | Source. |
|---|---|---|
| | sometimes dangerous to eat. (See also entry of May, 1956 above.) Apparently the water in parts of the shallow "lagoon" along the western side of Kiriwina become "murky" for a short time in April or May of most years. At night the discoloured water is phosphorescent, which is the signal for villagers to stop eating shellfish. Tumeri is a major dietary item of Kiriwinans—90 per cent of their shellfish diet—and villagers probably do not abstain from tumeri for a sufficiently long period following the phosphorescent displays to avoid occasional poisonings. The doctor at Losuia pointed out that illness from toxic shellfish is more common than health records show, since most villagers prefer to accept sickness and death at home rather than seek medical attention. | |
| 7th April, 1971. | Red water, over one square kilometre in area, was observed 14 kilometres east of Lae, Morobe District, about a kilometre off shore. It was apparently the third report of red tide near Lae that year. There was no sign of dead bird or marine life. A fisherman reported that he experienced irritation to his hands and forearms while fishing in the red water. The causative organism was described as being unicellular and often in 8 cell chains. (This description fits observations of dinoflagellate division. *Pyrodinium bahamense* commonly form 8 cell chains.) | DASF Files. Author's observations. |
| 18th April, 1971. | Red tide was observed in Marshall Lagoon, Central District. | DASF Files. |
| April-May 1971. | Red tide, later identified as *Pyrodinium bahamense* was present in Port Moresby Harbour during these months. It was apparently present in February and March also. | Discussion with biologists at the pearl farm in Fairfax Harbour, Port Moresby. |
| 31st May, 1971. | More red tide patches were sighted near Salamaua and inlets in the vicinity of Lasanga Island and Kui, Morobe District. | DASF Files. |
| November, 1971. | A red tide and numerous dead turtles and fish were found along the Morobe District coast between Lae and Morobe Harbour. Villagers ate the dead animals without ill effect. (See also report for November-December 1972 below.) | Discussions with Morobe villagers and Mr B. Burgess, Fisheries Officer, Lae, December, 1972. |
| December, 1971-May, 1972. | Red tide was observed to occur in Port Moresby Harbour and Fairfax Harbour almost continuously during this period. The dinoflagellate was again *P. bahamense*. Indigenous labourers at the pearl farm ate pearl oyster (*Pinctada maxima*) meat on several occasions during the time of red tides, apparently with no ill effect. | Discussions with pearl farm biologist Mr Asakawa. Also DASF Files. Identification of dinoflagellate by Dr Dodge, Birbeck College, University of London. |
| February-March, 1972. | During this time three patients were admitted to Port Moresby General Hospital suffering from paralytic shellfish poisoning. | Retrospective diagnosis after Walai fatalities. Unpublished PNG Health Dept document, reference 120/9/72. |
| 13th March, 1972. | Red tide was observed off Ela Beach, Port Moresby. | DASF Files. |
| 27th-29th April, 1972. | Extensive red tide, *P. bahamense*, was seen along the Central District coast between Walai and Port Moresby. Three indigenous children died and 20 other adults and children from Walai were hospitalised suffering with paralytic shellfish poisoning from the cockle *Anadara maculosa* (Motu name is Kuwadi). | Investigations by PNG Health Dept (Unpublished) document 120/9/72 Shellfish toxicity tests by DASF chemists; field observations by the author. |

**Observations.—*continued***

| Date. | Report. | Source. |
|---|---|---|
| 12th-23rd May, 1972 | Four indigenes including two children, from three villages in the Port Moresby area (Tatana, Vabukori, and Korobosea) were admitted to Port Moresby General Hospital with symptoms of paralytic shellfish poisoning. All had eaten bivalve shellfish. | PNG Health Dept document 120/9/72. |
| July, 1972 | One male indigene was admitted to Port Moresby General Hospital, suffering from mild paralytic shellfish poisoning after eating oysters (*Crassostrea echinata*) from the main wharf in Port Moresby Harbour. | PNG Health Dept document 120/9/72. Oyster identified by the author. |
| October, 1972. | Red tide was reported off the Morobe District coast about 40 kilometres east of Lae. | Mr B. Burgess, Fisheries Officer Lae, communication. |
| November-December, 1972. | Extensive red tide was reported along the Morobe coast between Lae and Morobe Harbour. *P. bahamense* blooms were observed in Morobe Lagoon. Mullet were dying and being eaten by villagers without harm. | Investigations by Mr B. Burgess and the author. |
| February-June, 1973. | Red tide (*Pyrodinium bahamense*) was visible in Port Moresby harbour on 15th February, 1973 for the first time since May, 1972. Subsequently it remained in the harbour almost continuously until the end of June. Bivalves from the harbour were found to be highly toxic, and warnings publicised: no poisonings were reported. | Investigations by the author.<br>Toxicity tests by DASF chemists. |
| February, 1973. | Red tide was seen in Milne Bay. Two types of red water are found in this area, a pink variety, probably *Trichodesmium*, and one which is associated with a pungent smell, presumably of dinoflagellate origin. The February red tide was of the latter type. See also entry of 26th June, 1973. | Observations by Mr N. Stanton, DASF officer. |
| 20th February, 1973. | A large crescent shaped patch of red tide was observed outside Amazon Bay, Central District. Paralytic shellfish poisoning deaths have occurred in this area. See Discussion. | Aerial observation. Mr F. Fletcher, DASF officer. |
| 9th March, 1973. | Extensive red tide was seen along the Central District coast from Kapa Kapa to Hood Point. | Aerial observation. Mr N. Stanton, DASF officer. |
| March, 1973. | Towards the end of the month, red tide was observed in areas between Bagum, Kondoka and Moputa villages, West New Britain. Nine cases of poisoning, six female and three male adult villagers of Kondoka, were named, but the report stated that "quite a number of people were reported sick". Symptoms were vomiting and general paralysis two to three hours after eating shellfish. The symptoms were severe among those who ate shellfish and also drank the "soup" in which they were boiled, but not severe in persons who ate the shellfish only. This situation provides a probable explanation for the 1963 Talasea fatality from eating food prepared in red tide contaminated water. Significant numbers of *P. bahamense* were found in plankton samples taken near Talasea on 10th May, 1973. | Dr Pulau, Health Officer, TALASEA.<br>Author's Investigations. |
| March-June, 1973. | Red tide, *P. bahamense,* was present intermittently on Central District coast between Port Moresby and Hood Point. No cases of poisoning were reported during this time. | Special weekly observation flights. |
| 11th May, 1973. | Red tide sighted in the vicinity of Rutiger Point, West New Britain. | Investigation by the author. |
| 26th June, 1973. | Red tide was sighted near Alotau, Milne Bay. A plankton sample taken there on 10th July, 1973 showed *Pyrodinium bahamense* to be the strongly dominant phytoplankton. | Aerial investigation by Mr T. O'Connell, DASF officer.<br>Author's plankton collection. |

## DISCUSSION

The above reports cover 13 separate outbreaks of red tide and/or paralytic shellfish poisoning, over a period of 18 years, which have resulted in 10 known deaths and over 160 treated illnesses.

*Table* 1 below indicates the relative severity of each outbreak. Deaths of marine life are noted in the table as either widespread and numerous (+ + +), many (+ +), few sightings (+) or none reported (−). *Figure* 1 shows the distribution of reported red tides and shellfish poisonings in Papua New Guinea.

The red tide species have been identified as *Pyrodinium bahamense* in the Morobe and Central Districts, Milne Bay and West New Britain (Talasea), and *Gonyaulax polygramma* in the Madang District. The causative organisms in the Trobriands and Manus Island remain unknown.

The ten deaths listed here are probably only a fraction of the total fatalities from paralytic shellfish poisoning in Papua New Guinea. Doubtless there have been other fatalities where villagers, unaware of the dangers of shellfish poisoning have attributed deaths to other causes, notably to the intervention of magic. There have also been fatalities, not reported to hospitals, where villagers are aware of the cause and generally abstain from certain shellfish during periods of red tide, as in the case of the Trobriand Islanders. Another such group are the villagers of Mailu, off Amazon

*Table* 1.—Summary of reports of red tides and/or shellfish poisonings in Papua New Guinea waters, 1956-173

| Year | Area | Apparent Red Tide Season | Human Fatalities | Non-fatal Cases | Dead Marine Life |
|---|---|---|---|---|---|
| 1956 | Trobriands | May-June | 1 | 97 | + + + |
| 1961 | Talasea, New Britain | January-May | 3 | 3 | + + |
| 1962 | Manus Island | May | 1 | 5 | − |
| 1963 | Talasea | May-July | 1 | 5 | + + |
| 1969 | Madang | September-November (?) | − | − | − |
| 1970-71 | Port Moresby | November-May | − | − | + |
| 1971 | Trobriands | April | 1 | 17 | − |
| 1971 | Lae | February (?)-April | − | − | − |
| 1971 | Lae | November | − | − | + + + |
| 1971-72 | Port Moresby | December-May | 3 | 28 | − |
| 1972 | Lae | October-December | − | − | + + |
| 1973 | Central District Coast, Port Moresby to Amazon Bay and Milne Bay | February-June | − | − | − |
| 1973 | Talasea | March-May | − | >9 | − |

Bay, Central District of Papua, who traditionally abstain from oysters, as well as *Anadara* and *Chama*, during times of red tides. These bivalves are known to become toxic in this District during blooms of *Pyrodinium bahamense*. A medical orderly from nearby Margarida reported that "many" people have been killed by paralytic shellfish poisoning in the past. Older villagers remember the deaths and the toxic properties of red tide are common lore in the area.

Past annual reports of the Health Department rarely listed individual forms of poisoning. There are over 7,000 cases annually in the New Guinea region alone, although fewer than ten deaths are recorded each year. Some of the annual reports for Papua in the 1950's presented detailed Health Department information. The 1957-1958 report mentions the death of an indigenous girl in the age group 1 to 10 years, from "shellfish poisoning". The only other shellfish poisoning death recorded in Papuan annual reports is that of a native labourer in 1927-1928. These two deaths were probably due to paralytic poisoning, although it is possible that the cause of death was allergy or bacterial food poisoning. Both are unlikely, especially the latter, since shellfish are collected fresh and usually boiled for some time before eating. This was the case in the 1972 Walai tragedy.

The water in which toxic bivalves are cooked also becomes toxic, a poisonous "soup". This provides further danger, since villagers commonly cook other foods in the soup left after boiling shellfish. One of the cases of paralytic shellfish poisoning at Walai (April, 1972) was of a person who had not eaten shellfish but who had eaten boiled foods prepared in the shellfish soup. In the West New Britain poisonings of March, 1973, poisoning symptoms were most severe where affected persons consumed the soup as well as the boiled shellfish. It is likely that the fatality there in 1963 was the result of a similar situation.

Other effects of New Guinea (*Pyrodinium*) red tide are also noteworthy: an allergic type of response and extensive fatalities of marine life. Neither is a constant feature of the outbreaks. The two recorded instances of "allergic" reactions were in areas where *Pyrodinium* is believed to have been responsible, Talasea (May, 1963) and Lae (April, 1971). However, the author and others have frequently dived into and through blooms for sampling purposes and to determine their depth. As well, concentrated samples of *Pyrodinium* from plankton hauls have been handled without harmful effect.

The destruction of marine life has varied greatly in the various outbreaks. The most extensive fish-kill was undoubtedly in 1956, while significant kills have also occurred in 1961, 1963, 1971 and 1972. At present it seems probable that these incidents can all be attributed to *Pyrodinium* red tides.

Fish kills from red tides result from either reduced oxygen levels or the poisonous effects of toxin released into the water. *Gonyaulax polyedra,* the California red tide organism, causes mortality in fish and molluscs by oxygen depletion associated with blooms of that dinoflagellate. It does not cause shellfish to become toxic (Sykes 1965). On the other hand, *Gymnodinium breve*, the Florida red tide, has a poisonous effect on fish. *Gymnodinium* blooms also emit a gas or vapour which is irritating to the eyes, nose and throat (Torpey and Ingle 1966). As well, it has recently been found that they produce some toxicity in bivalve shellfish (Morton and Burklew 1969).

The New Guinea (*Pyrodinium*) red tide affects air-breathing turtles and dolphins as well as fish, which indicates involvement of the toxin rather than simple suffocation. In this respect, the New Guinea red tide resembles *Gymnodinium*. However, fish kills are a more regular feature of blooms of the latter. Interestingly, villagers have eaten fish and turtles washed ashore during New Guinea red tides without ill effect (Lae 1971 and 1972).

It is difficult to find a seasonal pattern in the red tide outbreaks summarised in *Table* 1. Red tides have occurred in every month of the year except August. For most of the New Guinea islands and the Milne Bay area, dangerous months appear to be from January to July inclusive. On the Central District coast of Papua, November to May are indicated as red tide months, corresponding roughly with the rainy season. The situation is more complicated in Lae and the Morobe District coast. Probably red tides can be expected there at any time between October and April inclusive. In Madang District, the known red tide months, September-November, may represent part of the season only.

However, dinoflagellates are not the only sources of discoloured waters in Papua New Guinea. As a result of the Walai fatalities in 1972, the importance of red tides as potential health hazards in Papua New Guinea has been stressed, and all recent reports of discoloured waters have been investigated to determine their nature. Other than dinoflagellate red tides, the following blooms have been observed.

1. *Salps.*—In July and August, 1972, wide orange streaks were observed inside and close to the outer reefs in the sea off the Central District coast about 70 kilometres south east of Port Moresby. From the air these patches were similar to those of *Pyrodinium*, but later sampling revealed the source of the colour to be a bloom or swarm of salps (*Thalia* sp.). A less pronounced swarm of the same species occurred over shallow reefs in Port Moresby harbour in December, 1972.

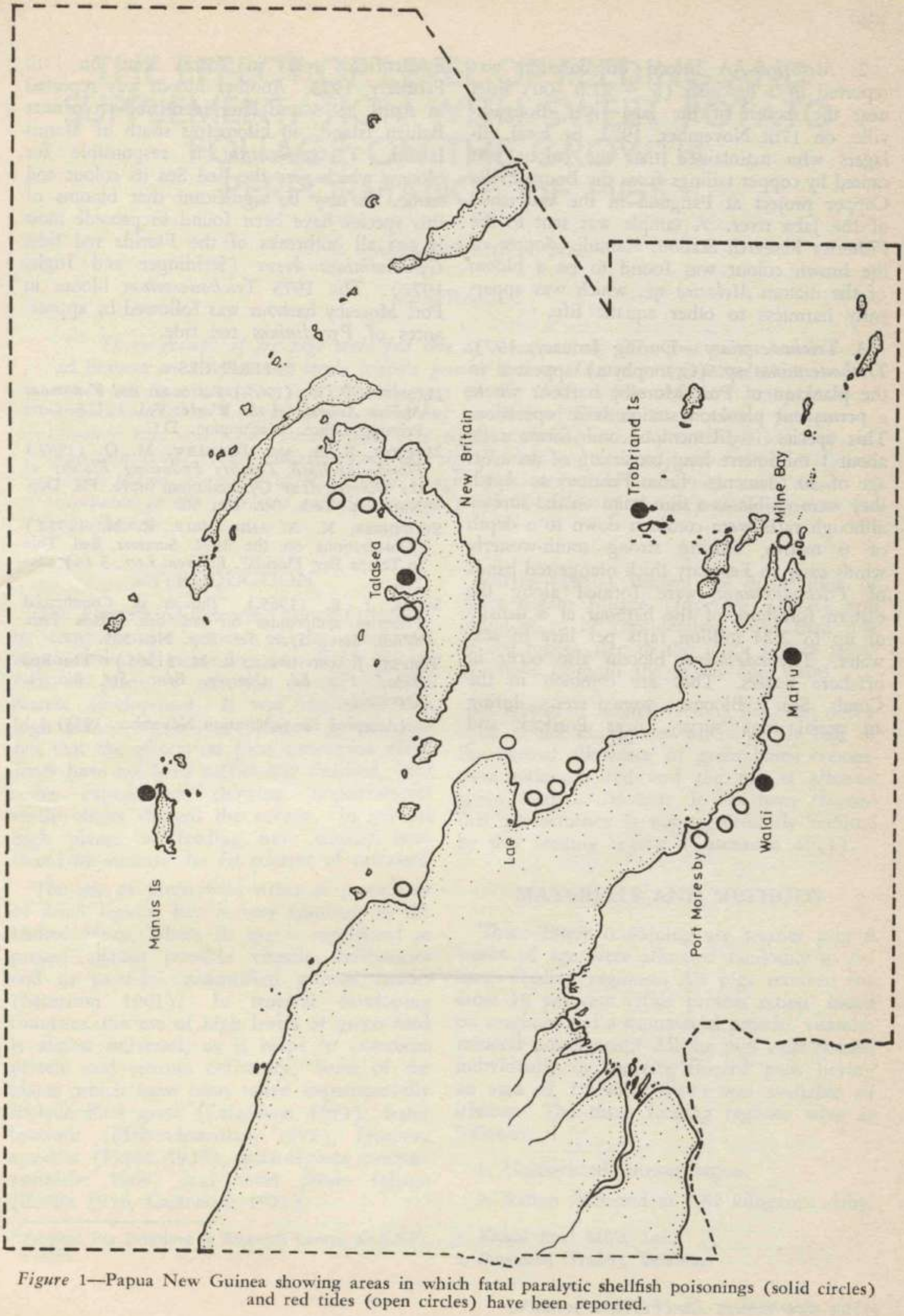


*Figure* 1—Papua New Guinea showing areas in which fatal paralytic shellfish poisonings (solid circles) and red tides (open circles) have been reported.

2. *Melosira.*—A brown discoloration was reported in a brackish (S = 21.0°/00) inlet near the mouth of the Jaba river, Bougainville, on 17th November, 1972, by local villagers who maintained that the colour was caused by copper tailings from the Bougainville Copper project at Panguna in the watershed of the Jaba river. A sample was sent to the Fisheries Research Station, Kanudi. Source of the brown colour was found to be a bloom of the diatom *Melosira* sp., which was apparently harmless to other aquatic life.

3. *Trichodesmium.*—During January, 1973, *Trichodesmium* sp. (Cyanophyta) appeared in the plankton of Port Moresby harbour where a permanent plankton station is in operation. This species is filamentous and forms rafts about 1 millimetre long consisting of an average of 30 filaments. From February to April, they were visible as a thin scum on the surface although rafts were common down to a depth of 6 metres. During strong south-westerly winds early in February thick orange-red bands of *Trichodesmium* were formed along the eastern foreshore of the harbour at a density of up to 2.24 million rafts per litre of seawater. *Trichodesmium* blooms also occur in offshore waters. They are common in the Coral Sea. Blooms were seen during an aerial tuna survey, near Portlock and Easternfields reefs in Torres Strait on 17th February, 1973. Another bloom was reported in April, 1973 and later identified from near Baluan Island, 40 kilometres south of Manus Island. *T. erythraeum* is responsible for blooms which give the Red Sea its colour and name. It may be significant that blooms of this species have been found to precede most if not all outbreaks of the Florida red tide, *Gymnodinium breve* (Steidinger and Ingle, 1972). The 1973 *Trichodesmium* bloom in Port Moresby harbour was followed by appearances of *Pyrodinium* red tide.

REFERENCES

HALSTEAD, B. W. (1965.) *Poisonous and Venomous Marine Animals of the World*, Vol. 1, U.S. Govt Printing Office, Washington, D.C.

MORTON, R. A. AND BURKLEW, M. Q. (1969.) *Florida Shellfish Toxicity Following Blooms of the Dinoflagellate* Gymnodinium breve. Fla. Dep. Nat. Res. Tech. Ser. No. 60.

STEIDINGER, K. A. AND INGLE, R. M. (1972.) "Observations on the 1971 Summer Red Tide in Tampa Bay, Florida". *Environ. Lett.*, 3 (4):271-278.

SYKES, J. E. (1965.) "Bureau of Commercial Fisheries symposium on red tide". U.S. Fish. Wildl. Serv., *Spec. Sci. Rep.* No. 521.

TORPEY, J. AND INGLE, R. M. (1966.) "The Red Tide." *Fla. Bd. Conserv. Educ. Ser.* No. 1. (revised).

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# THE EFFECT OF LEVEL OF FEEDING AND SUPPLEMENTATION WITH SWEET POTATO FOLIAGE ON THE GROWTH PERFORMANCE OF PIGS

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## ABSTRACT

*Three groups of six pigs were fed one of three rations. The first group received* ad libitum *an* 18 *per cent crude protein grower ration. The second received the same ration up to a maximum of* 1.82 *kilogram* (4 *lb*) *daily, while the third group was also restricted to* 1.82 *kilograms daily but received* ad libitum *sweet potato foliage. Growth rate and food consumption were significantly increased by the high plane of nutrition, while food conversion ratio was significantly and adversely affected. Feeding sweet potato adversely affected both weight gain and food conversion ratio when compared to the restricted unsupplemented group. Neither of the differences reached significance.*

## INTRODUCTION

The Agricultural Research Council (1967) in its comprehensive review of the nutritional requirements of swine has considered the effects of plane of nutrition on growth and carcass development. It was concluded that high planes of feeding increase growth rate but that the effects on food conversion efficiency have not been sufficiently clarified, with some experiments showing improvements while others showed the reverse. In general high planes of feeding have usually been found to increase the fat content of carcasses.

The use of green feed either as pasture or as dried legume hay is very common in the United States, where its use is considered to protect against possible vitamin deficiencies and to provide unidentified growth factors (Morrison 1961). In tropical developing countries, the use of high levels of green feed is almost universal, as it helps to overcome protein and vitamin deficiency. Some of the plants which have been tested experimentally include Para grass (Catanaoan 1971), water hyacinth (Mahendranathan 1971), *Ipomoea aquatica* (Payne 1956), grass-legume mixture (Modebe 1969) and sweet potato foliage (Zarate 1956, Catanaoan 1971).

Zarate (1956) studied the digestibility of sweet potato foliage (*Ipomoea batatas*) and found it to be considerably lower than that of the tubers, due to the much higher levels of crude fibre in the leaves and stems.

A system of limited feeding has been developed in the Philippines whereby only half of the normal allowance of grain based concentrate ration is fed and the pig is allowed green feed *ad libitum*. It has been claimed that performance is not significantly reduced by this feeding regime (Catanaoan 1971).

## MATERIALS AND METHODS

Three litters containing six weaner pigs 8 weeks of age were allocated randomly to the three feeding regimes. All pigs received the same 18 per cent crude protein ration[1] based on sorghum and a commercial protein, vitamin-mineral supplement.[2] All the pigs were housed individually in concrete floored pens having an area of 1.35m². Water was available *ad libitum*. The three feeding regimes were as follows:

1. Unrestricted grower ration.
2. Ration restricted to 1.82 kilograms daily.

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1. Kaiani Feed Mills, Lae.
2. Provincial Traders, Brisbane.

3. Ration restricted to a maximum of 1.82 kilograms daily (4 lbs).

   When pigs had completed their daily quota they were allowed free access to sweet potato foliage.

During the early stages of the experiment, pigs on the restricted plane failed to consume all of their daily allocation which reduced mean daily consumption over the whole experiment.

Pigs were fed daily, and uneaten residues weighed and consumption recorded. Pigs were weighed weekly until the end of the experiment 85 days later.

## RESULTS AND DISCUSSION

The results of the experiment are shown in *Table* 1. Compared to the restricted unsupplemented ration, *ad libitum* feeding increased rate of gain by about 13 per cent. However consumption over the experimental period was increased by 47 per cent, a fact which is borne out in the much inferior food conversion ratio. It would appear from these results that restricted feeding resulted in a saving in feed required per pound of gain of about 30 per cent. This represents a considerably higher saving in feed due to restriction than has been reported by any of the recent reviewers (Lucas and Calder 1956, A.R.C., 1967, Vanschoubroek *et al.* 1967). The latter author has developed prediction equations based on the published literature which show that on average a decrease of one per cent in food consumption leads to a saving in feed of 0.31 per cent. On this basis, the saving in feed for the restricted group should have been of the order of 15 per cent not 30 per cent as recorded.

That it was not may be a reflection of two factors:

1. The data of Vanschoubroek *et al.* (1967) refer to bacon pigs from 30 to 90 kg. The present study was conducted at much lighter weights.
2. The possibility that nutritional requirements and growth rates are different in tropical environments.

Several authors have recorded that high temperatures decrease weight gain, intake and adversely affect food conversion ratio (Heitman *et al.* 1958, Sugahara *et al.* 1970, Holmes 1971). In addition there is the suggestion that to compensate for the lower energy intakes of swine at high temperatures, rations containing higher protein levels than are recommended for temperate climates may be required. (Devendra and Clyde-Parris 1970).

Day and night temperatures at Goroka average 28.3° C and 15.3° C respectively. Day temperatures are considerably higher than the temperature range for optimal growth of 15 to 20° C as found by Mount (1968).

The feeding of sweet potato vines did not significantly affect the performance of pigs compared to the restricted control. In fact performance was adversely affected. It is however possible that a genetic factor is at work. Zarate (1956) has shown that the

***Table* 1.—Performance of growing pigs fed at various levels of nutrition**

| Parameter | Treatment | | |
|---|---|---|---|
| | Ad-libitum ration | Restricted ration | Restricted ration plus sweet potato foliage |
| Number of pigs | 6 | 6 | 6 |
| Mean initial weight (kg) | 16.1 ± 3.4 | 15.1 ± 2.5 | 15.8 ± 4.6 |
| Mean Final weight (kg) | 59.2 ± 4.1 | 53.0 ± 3.8 | 50.8 ± 8.2 |
| Mean daily gain (g) | [1] 507 ± 30 [ab] | 447 ± 30 [a] | 410 ± 54 [b] |
| Mean daily grower ration consumption (kg) | 2.46 ± 0.33 [ab] | 1.67 ± 0.06 [a] | 1.65 ± 0.09 [b] |
| Mean food conversion ratio. (grower ration) | 4.88 ± 0.76 [ab] | 3.76 ± 0.22 [a] | 4.07 ± 0.52 [b] |

[1] Means in the same row with the same superscript are significantly different. $P < 0.05$.

digestibility of fibre in sweet potato vines was much higher in native Philippine pigs than either the Berkshire or the Berkjala (a hybrid pig developed from the indigenous Jajala breed and the Berkshire) and it is possible that exotic commercial breeds such as were used in the present experiment are unable to successfully digest high fibre rations. There is further evidence of genetic differences in fibre digestibility from the work of Farries and Angelowa (1968) who found that European wild hogs were able to digest fibre more efficiently than German Landrace.

## CONCLUSIONS

The use of *ad libitum* grain feeding is not recommended as it reduces feed efficiency. The supplementation of standard rations with sweet potato foliage was not found to improve performance.

### REFERENCES


AGRICULTURAL RESEARCH COUNCIL (1967). The Nutrient Requirements of Farm Livestock No. 3 Pigs. Technical Reviews and Summaries. A.R.C. London.

CATANAOAN, C. (1971). High Forage—Limited concentrate a winning combination for swine. *Wld. Farm*, 13(5):3.

DEVENDRA, C. AND CLYDE-PARRIS (1970). Optimal crude protein levels for growing and finishing pigs in a tropical environment. *Trop. Anim. Health Prod.*, 2:162-165.

FARRIES, VON E. AND ANGELOWA, L. (1968). Vergleichende Untersuchungenzur Nahrstoffverdanlichkeit und Stickstoff retention bei veredelten Landschweinen Wildschweinen and F1-Kreuzungen Z. *Tierphysiologie*, 23:263-266.

HEITMAN, H., KELLY, C. F. AND BOND, T. E. (1958) Ambient air temperature and weight gain in swine. *J. Anim. Sci.*, 17:62-67.

HOLMES, C. W. (1971). Growth and Backfat Depth of Pigs Kept at a High Temperature. *Anim. Prod.*, 13:521-527.

LUCAS, I. A. M. AND CALDER, A. F. C. (1956). The response of different types of pigs to varying levels of feeding from weaning to bacon weight with particular reference to carcass quality. *J. Agric. Sci.*, 47:287-323.

MAHENDRANATHAN, T. (1971). Water hyacinth has a value as a pig feed. *Pig Farmer*, January 1971, 599-607.

MODEBE, A. N. A. (1969). Preliminary studies on the effect of limited and unlimited systems of feeding and of tropical type grass legume clippings fed in dry lot on the growth rate, economy of gain and carcass quality of growing fattening pigs. *J. West Afr. Sci. Assoc.*, 7:116-126.

MOUNT, L. E. (1968). *The climatic physiology of the pig.* Edward Arnold, London.

MORRISON, F. B. (1961). *Feeds and Feeding.* Abridged. Morrison Publishing Co., Clinton.

PAYNE, W. J. A. (1956). *Ipomoea reptans*, Poir a useful tropical fodder plant. *Trop. Agric. Trin.*, 33:302-305.

STEEL, R. G. D. AND TORRIE, J. H. (1960). *Principles and Procedures of Statistics.* McGraw Hill, New York.

SUGAHARA, M., BAKER, D. H., HARMON, B. G. AND JENSEN, A. H. (1970). Effect of ambient temperature on performance and carcass development in young swine. *J. Anim. Sci.*, 31:59-62.

VANSCHOUBROEK, F., DE WILDE R. AND LAMPO, Ph. (1967). The quantitative effects of feed restriction in fattening pigs on weight gain, efficiency of feed utilisation and backfat thickness. *Anim. Prod.*, 9:67-74.

ZARATE, J. J. (1956). The digestibility by swine of swine of sweet potato vines and tubers cassava roots and green papaya fruits. *Philipp. Agric.*, 60:78-83.


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# COCONUT MEAL FOR GROWING PIGS

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ABSTRACT

*A total of 79 pigs were used in three experiments to evaluate coconut meal in rations for growing pigs at levels up to* 30 *per cent of the ration. There were no significant treatment effects up to this level of inclusion, although there was a trend to reduced performance with increasing coconut oil meal inclusion.*

## INTRODUCTION

Coconut oil meal is produced from the dried endosperm of the coconut, *Cocos nucifera.* The meal produced in Papua New Guinea is usually exported to Europe where it is widely used as feed for dairy cattle. Because of its wide availability in the tropics it has been investigated by a number of authors as a possible ingredient of pig rations (Grieve, Osbourn and Gonzales 1966, Adzic, Gradinae, Bozickovic and Zivkovic 1966, Springhall 1969, Cresswell and Brooks 1971b). Cresswell and Brooks (1971a) have also studied the digestibility and chemical composition of coconut meal in detail. Arek (unpublished 1971) has studied the effect of local coconut meal on the growth and carcass development of the pig.

There appears to be disagreement in the published literature on the value of coconut meal for pigs with some experiments showing deleterious effects at levels higher than 20 per cent and others with no significant effects on performance at levels up to 30 per cent of the ration.

The experiments described was designed to further evaluate coconut meal as a potential ingredient of pig rations in Papua New Guinea.

## MATERIALS AND METHODS

Three separate experiments were conducted, one at Rabaul at sea level, and two at Goroka at an altitude of 1,600 metres.

In the first experiment each of three litters of nine weaner pigs were allocated at random into three treatment groups. Each litter-treatment group containing three pigs was housed in a concrete floored pen having an area of 4.5 $m^2$. Feed and water were available *ad libitum*. The pigs remained on the treatments until they reached a weight of 55 kg liveweight.

The second experiment contained four treatment groups of seven crossbred weaner pigs. Each treatment group was housed in half covered concrete pens having an area of 27 $m^2$. Feed and water were available *ad libitum* during the course of the experiment which lasted for 70 days.

In the third experiment each of three litters of eight weaner pigs were allocated at random to one of four treatment groups. Pigs were housed individually in pens having an area of 1.4 $m^2$. Feed and water were available without restriction. The experiment lasted for 77 days.

The rations used in the three experiments are shown in *Table* 1. The first experiment which was of a preliminary nature was designed simply to study the effect of substituting coconut oil meal for a commercial 18 per cent crude protein grower ration without attempting to balance the ration. In experiments two and three the rations were calculated to contain approximately equivalent levels of protein and micronutrients. The data in the first experiment were analysed for variance. The second and third experiments were analysed by covariance to eliminate the effects of varying initial weight (Steel and Torrie 1960).

## RESULTS AND DISCUSSION

There were no significant differences in growth performance due to treatment in any of the three experiments. There was a trend

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*Table* 1.—Composition of experimental rations

| Ration number | Experiment 1 | | | Experiments 2 & 3 | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Coconut oil meal (kg) | — | 16.5 | 29 | — | 10 | 20 | 30 |
| Ground sorghum (kg) | 80 | 67 | 57 | 80.5 | 73 | 64.5 | 58 |
| Protein-vitamin-mineral supplement (kg)[1] | 20 | 16.5 | 14 | 19.5 | 17 | 14.5 | 12 |
| Bone ash (g) | | | | — | 264 | 528 | 792 |
| Salt (g) | | | | — | 88 | 172 | 264 |
| Vitamin-mineral supplement (g)[2] | | | | — | 22 | 44 | 66 |
| Calculated crude protein (%) | 18.2 | 18.4 | 18.6 | 17.9 | 18.0 | 17.8 | 17.8 |

[1] In experiment 1, the supplement was Hutmills, Melbourne, and contained 55 per cent crude protein, 2 per cent salt, Vit.A 74,800 I.U/kg., Vit.D3 12,800 I.U./kg., Vit.E 61.6 I.U/kg., Vit.B2 26.4 mg.

In experiment 2, Provincial Traders supplement was used. This contained 55 per cent crude protein, 4 per cent salt, Vit.A 60,100 I.U./kg., Vit.D 3,960 I.U./kg., Vit.E 88 I.U/kg., Vit.B2 16.5 mg/kg.

[2] Contains Vit.A 3,300,000 I.U/kg., Vit.D3 660,000 I.U./kg., Vit.B2 1375 mg/kg., Vit.E 3,300 I.U./kg., Cu 22 g/kg., 1 O.22 g/kg., Fe 88 g/kg., Ma 44 g/kg., Zn 110 g/kg.

in all three experiments for performance to deteriorate with the higher levels of coconut oil meal.

Adzic *et al.* (1966) and Cresswell and Brooks (1971b) recorded reduced growth performance with levels of coconut oil meal higher than 10 per cent of the ration. This has been attributed to the low digestibility of protein in the meal (Cresswell and Brooks 1971a).

Performance in experiment three was uniformly inferior to that in experiment two. The difference is considered to be due to the individual feeding practised in experiment three, which imposes stress on the animals.

*Table* 2.—The growth performance of pigs fed rations in which coconuts oil meal was substituted (Experiment 1)

| Level of coconut oil meal (%) | 0 | 16 | 29 |
|---|---|---|---|
| Number of pigs | 9 | 9 | 9 |
| Initial weight (kg) | 17.4 | 17.0 | 17.0 |
| Final weight (kg) | 54.9 | 55.8 | 55.6 |
| Days on test | 60 | 74 | 84 |
| Average daily gain (g) | 560 | 520 | 460 |
| " food consumption (kg) | 1.70 | 1.72 | 1.37 |
| Feed conversion ratio | 3.03 | 3.30 | 2.98 |

A contributing factor in the performance of pigs fed coconut meal was the reduction in voluntary feed intake that occurred as levels rose. This was found in all three of the present experiments and was also found by Cresswell and Brooks (1971b). This is rather unexpected as due to the high fibre content of coconut oil meal an increase in consumption would be more usual (Agricultural Research Council 1967). It is possible that there is some factor in the meal which reduces voluntary consumption.

*Table* 3.—The effect of coconut oil meal in rations for growing pigs (Experiment 2)

| Level of coconut oil meal (%) | 0 | 10 | 20 | 30 |
|---|---|---|---|---|
| Number of pigs | 7 | 7 | 7 | 7 |
| Average initial wt. (kg) | 18.6 | 19.5 | 20.0 | 18.2 |
| Average final wt. (kg) | 61.8 | 61.7 | 59.1 | 59.2 |
| Average daily gain (g) | 617 | 600 | 557 | 584 |
| Av. food consumption (kg) | 1.81 | 1.81 | 1.78 | 1.78 |
| Av. food conversion ratio | 2.93 | 3.01 | 3.19 | 3.05 |

*Table* 4.—The effect of coconut oil meal in ration for growing pigs (Experiment 3)

| Level of coconut oil meal | 0 | 10 | 20 | 30 |
|---|---|---|---|---|
| Number of pigs | 6 | 6 | 6 | 6 |
| Average initial wt. (kg) | 17.3 | 18.3 | 17.0 | 15.6 |
| Average final wt. (kg) | 45.4 | 41.8 | 38.0 | 36.7 |
| Average daily gain (g) | 589 | 543 | 493 | 476 |
| Average daily food consumption (kg) | 2.20 | 2.08 | 1.86 | 1.87 |
| Average food conversion ratio | 3.67 | 3.83 | 3.81 | 3.89 |

Feed conversion ratio was adversely affected in two of the three experiments. In experiment one this was not observed. Such a finding is not unexpected in view of the reduced consumption and poor digestibility of coconut oil meal.

The results of the three experiments described above show that at levels of up to 30 per cent inclusion of coconut oil meal no statistically significant effects were observed on growth performance of pigs. There was a trend however for performance to decline with high levels of inclusion. Further work is required to study the effects of coconut meal on carcass quality.

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REFERENCES

ADZIC, A., GRADINAE, D., BOZICKOVIC. S. AND ZIVKOVIC, S. (1966). Comparative trials with fishmeal dried skim milk soyabean meal and coconut meal as the protein source in the feeding of growing pigs. *Stocarstvo.*, 20:43.

AGRICULTURAL RESEARCH COUNCIL (1967). Nutrient Requirements of Farm Livestock No. 3 Pigs. Technical Reviews and Summaries. A.R.C. London.

AREK, T.C.P. (1971). The effect of coconut oil meal in growing pig rations on performance, carcass measurements and the economics of feeding. Unpublished report. Vudal Agric. College, East New Britain.

CRESSWELL, D. C. AND BROOKS, C. C. (1971). Composition, apparent digestibility and energy evaluation of coconut oil and coconut meal. *J. Anim. Sci.*, 33:366-369.

CRESSWELL, D. C. AND BROOKS C. C. (1971). The effect of coconut meal on Coturnix quail and of coconut meal and coconut oil on performance carcass measurements and fat composition in swine. *J. Anim. Sci.*, 33:370-375.

GRIEVE, C. M., OSBOURN, D. F. AND GONZALES, F. O. (1966). Coconut oil meal in growing and finishing rations for swine. *Trop. Agric.*, 43:257-261.

SPRINGHALL, J. A. (1969). The use of selected local ingredients for pig rations in the Territory of Papua New Guinea. *Papua New Guinea agric. J.*, 21:76-87.

STEEL, R. G. D. AND TORRIE, J. H. (1960). *Principles and procedures of statistics.* McGraw Hill, New York.

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# PRELIMINARY OBSERVATIONS ON THE GROWTH AND PRODUCTION OF BANANAS IN THE NORTHERN DISTRICT OF PAPUA NEW GUINEA

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## ABSTRACT

*Growth and production measurements were taken from three varieties: Dwarf Cavendish, Giant Cavendish and Tui grown on a volcanic ash sandy loam soil over a 16-month period at Lejo experimental station in the Northern District.*

*The dry season was exceptionally severe. However the main factor limiting yields appeared to be Sigatoka leaf spot* (Cercospera musa). *The level of this disease was markedly reduced by the dry season, but despite a constant spraying programme using a mancozeb-oil mixture with shoulder-mounted misting machines, it increased in severity as the wet season advanced. There was a close correlation between bunch weight and the degree of Sigatoka as measured by number of functional leaves at harvest.*

*Giant Cavendish maintained the heaviest bunch weight throughout most of the trial, but this cannot be regarded as a true varietal test due to the variation in level of Sigatoka infection between the three varieties. Failure to properly control Sigatoka was partly put down to failure to give adequate protection to newly emerging leaves.*

*Growth rates of all the three varieties was markedly reduced during the dry season and a close correlation between rainfall and growth rate existed during the first nine months of the trial. There was some evidence of parental dominance on young suckers of Tui and Dwarf Cavendish but not Giant Cavendish. Tui and Dwarf Cavendish showed significantly greater growth rates during the early life of a sucker and although not significant this could also be the case with Giant Cavendish. Level of Sigatoka infection appeared to have no effect on growth rates of any of the three varieties.*

*Time taken to throw a bunch varied significantly between varieties with Dwarf Cavendish taking the least time and Tui the longest.*


## INTRODUCTION

Bananas have been grown on a subsistence basis in the Northern District for a long time and form an important part of the human diet. With some interest being shown in the commercial production of this crop for export it was considered necessary to study yield and growth variations in some detail.

The literature indicates that environmental factors such as temperature and rainfall can largely influence the growth and yield potential of bananas (Turner 1971, Simmonds 1959, Wardlaw 1961). Simmonds (1959) suggests that a mean monthly temperature of less than 21 degrees C would result in some check in growth as it would probably imply that the mean minimum temperatures would be in the region of 15.5 degrees C. Temperatures are uniformly higher (greater than 21 degrees C) in the Northern District with only slight seasonal variation (Slatyer 1964). Temperature cannot therefore be regarded as a major limitation to growth or production at any time in the Northern District. On the other hand, rainfall is seasonal and a definite dry period does exist.

The aim of the trial was therefore to gain some knowledge of the main factors influencing growth and yields of these commercial banana types under Northern District conditions.

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## MATERIAL AND METHODS

The varieties tested included Dwarf Cavendish, Giant Cavendish and a tall robust growing type locally called Tui, but bearing a strong resemblance to the Gros Michel described by Simmonds (1959).

The total area sampled was approximately 2/3 hectare. The three varieties were randomly planted throughout this block on a 3.6 by 3.6 metre spacing, giving a total of 510 stools. Due to the relatively wide spacing and severity of leaf spot it was considered that the taller varieties did not gain special advantage from shading of the smaller ones.

The suckers were initially planted in November, 1969 in a volcanish ash sandy loam soil which had been growing cocoa and *Leucaena leucocephala* for over ten years. Results of soil analysis performed on samples obtained in October, 1971 are as outlined in *Table* 1.

*Table* 1.—Results of chemical analysis of Lejo soil

| Depth | pH | Nitrogen % | Carbon % | Olsen P ppm | Exchangeable rations | | | | Total Exchange Capacity | Base Satn. % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ca m.e.% | Mg m.e.% | K m.e.% | Na m.e.% | | |
| 0-15 cms | 6.7 | 0.18 | 1.8 | 16.0 | 11 | 1.9 | 0.3 | 0.4 | 13.6 | 100 |
| 15-30 " | 6.0 | 0.13 | 1.3 | 7.0 | 8 | 1.4 | 0.4 | 0.7 | 10.5 | 98 |

There was no attempt at pruning until October, 1970, by which stage there were several well developed suckers clustered around the mother plant on every stool. During the pruning some retarded mother plants were knocked out where a well developed sucker was prominent. Another smaller sucker was also left so that there would have been two suckers per stool. When the mother plant bunched, another sucker was allowed to develop. There were therefore two to three plants per stool depending on the age of the mother plant. This system was maintained throughout the trial.

Harvesting commenced in December, 1971. Due to a very severe attack of Sigatoka leaf spot disease (*Cercospera musa*) bunches were initially often harvested when no leaves remained on the stem and fingers were only half full. When incidence of leaf spot decreased permitting fruit to fill out before ripening, bunches were harvested at the full stage.

Attempts to control Sigatoka were commenced in February, 1972. The mixture used was 2.25 kg mancozeb, 2.8 litres superior white oil per hectare. This was applied with shoulder mounted misting machines. Initially spraying intervals were irregular (3 to 5 weeks) until July, 1972 when it was changed to a regular 3-weekly spray and then to every fortnight in early November, 1972.

An estimate was made on the severity of leaf spot disease by estimating the number of functional leaves or part thereof in the field at harvest. For example if there were three leaves remaining at harvest with an average of 50 per cent infection then the number of functional leaves would be 1.5. The estimate of Sigatoka is therefore a negative index and in fact is an estimate of freedom from Sigatoka.

No weeding was carried out during the trial but a creeping vine (*Momordica charantia*) established itself naturally and was very successful in controlling growth of other weeds. Later it was discovered that the roots of this vine were infected with the root knot nematode *Meloidogyne incognita*. This nematode was not considered to be pathogenic on the banana roots. However two other species, *Radophilus similis* (Cobb.) and *Helicotylenchus* spp., were extracted from banana roots following observations that some stems carrying immature bunches toppled over in August, 1972. A small number of stools continued to topple over during the remainder of the trial. However no nematicide was added at any stage.

During November, 1971 a 0.1 per cent solution of Heptachlor was sprayed around the base of each stool to combat an infestation of banana weevil borer (*Cosmopolites sordidus* Germ.). A further build-up was

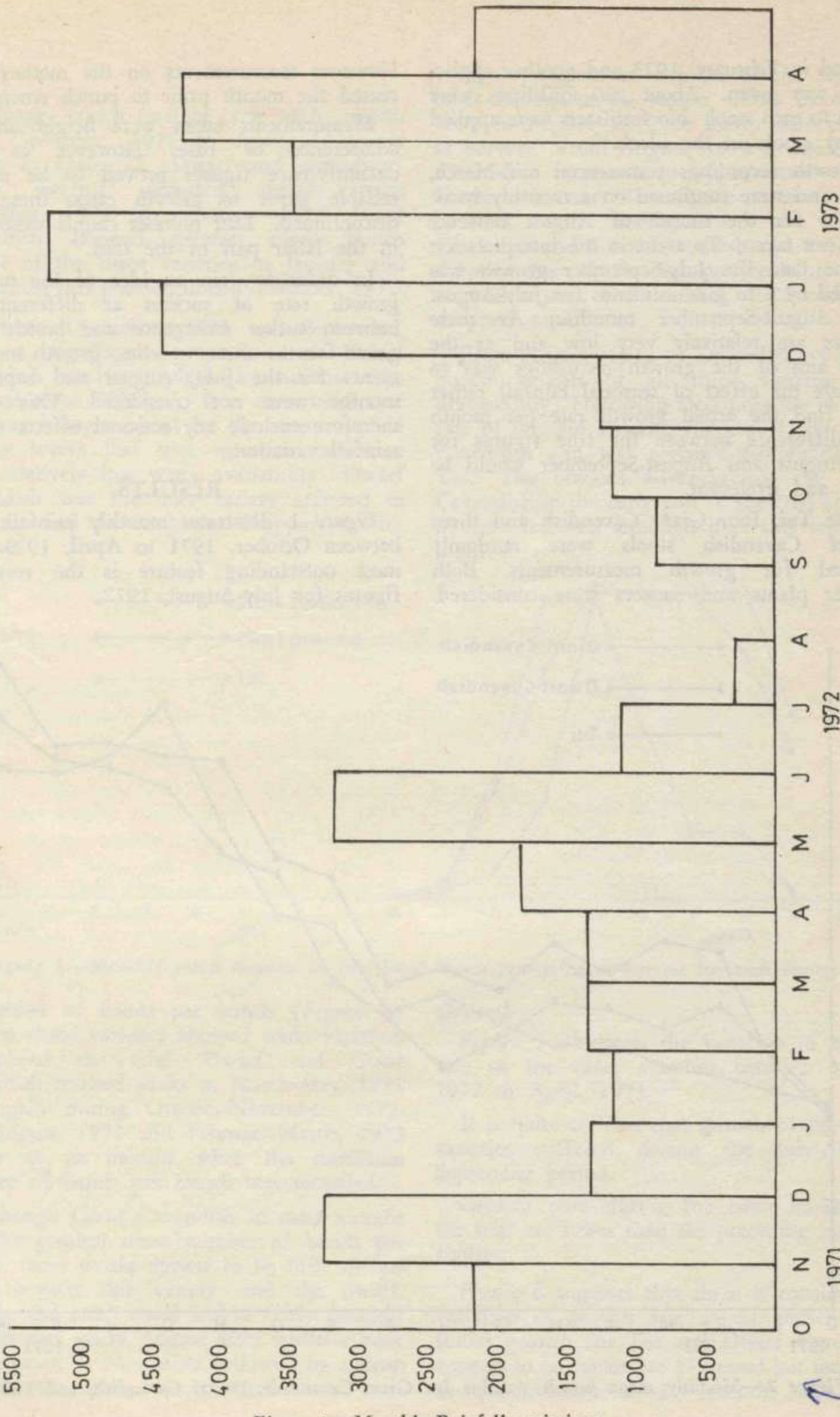


*Figure* 1.—Monthly Rainfall variations.
Rainfall in (mm)

noticed in February, 1973 and another application was given. About 500 millilitres were given to each stool. No fertilizers were applied to any stools in the block.

Growth recordings commenced mid-March, 1972 and were continued on a monthly basis. Figures for the month of August however were not taken. To assist in the interpretation of the data the July-September growth was divided by 2 to give estimates for July-August and August-September months. As these figures are relatively very low and as the main aim of the growth recordings was to evaluate the effect of seasonal rainfall rather than find the actual growth rate per month any difference between the true figures for July-August and August-September would be small and irrelevant.

Five Tui, four Giant Cavendish and three Dwarf Cavendish stools were randomly selected for growth measurements. Both mother plants and suckers were considered. However measurements on the mother plant ceased the month prior to bunch emergence.

Measurements taken were height and circumference of base. However as basal circumference figures proved to be an unreliable guide to growth rates, these were discontinued. Leaf number counts were taken in the latter part of the trial.

In order to gain an idea of the monthly growth rate of suckers at different ages between sucker emergence and bunch emergence for the three varieties, growth measurements for the July, August and September months were not considered. This would therefore exclude any seasonal effects due to rainfall variation.

## RESULTS

*Figure* 1 illustrates monthly rainfall totals between October, 1971 to April, 1973. The most outstanding feature is the very low figures for July-August, 1972

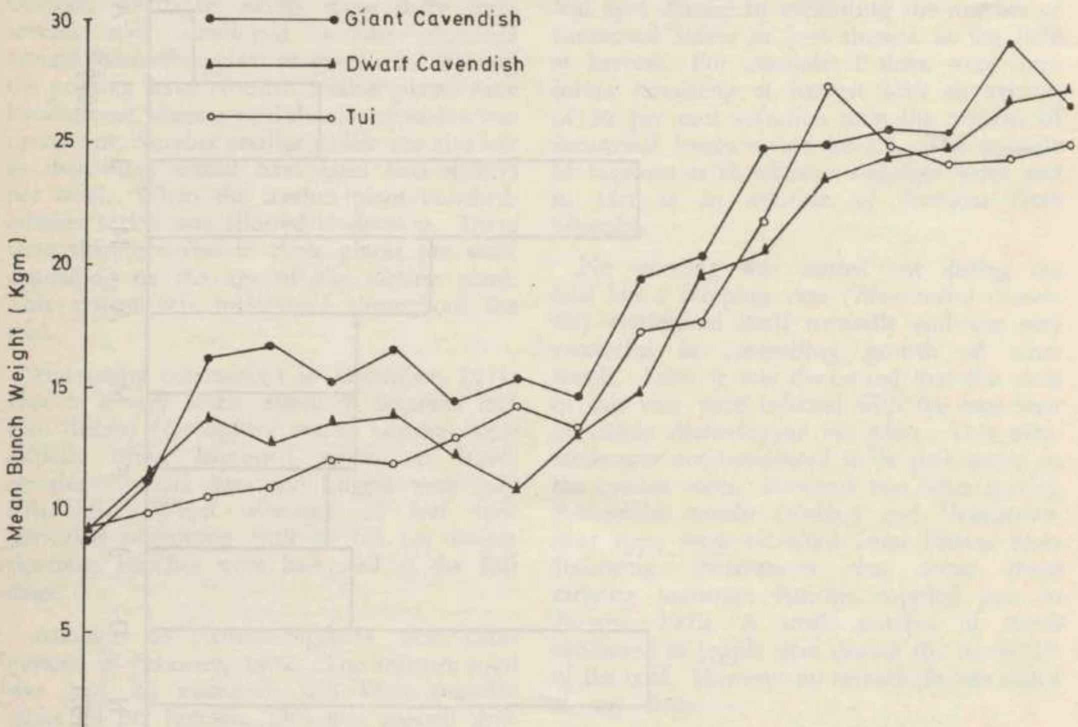


*Figure* 2.—Monthly mean bunch weights for Giant Cavendish, Dwarf Cavendish, and Tui.

*Yields*

Average bunch weight for each month from December, 1971 to April, 1973 are shown in *Figure* 2. Dwarf and semi-dwarf bunch weights increased sharply from December, 1971 to February, 1972. Giant Cavendish attained greatest mean bunch weight of the three varieties in January and maintained this position until November, 1972.

Between December, 1971 and September, 1972 a significant proportion of Dwarf Cavendish bunches displayed a condition often referred to as "Choke". It is considered that this was brought about by the stress applied by the severe leaf spot infection combined with relatively low water availability. Dwarf Cavendish was the only variety affected in this crop and the symptoms disappeared after October.

*Figure* 3 gives an estimate of the Sigatoka level throughout the season. From December, 1971 to August, 1972 no leaves were present at harvest. From August, 1972 to December, 1972 this increased to approximately three leaves at harvest. This figure remained fairly constant until March, 1973 for Dwarf Cavendish and Giant Cavendish and then both dropped for April. Tui on the other hand reached a peak in December, 1972 and then dropped rapidly.

From August, 1972 to December, 1972 the bunch weights of all three varieties rose dramatically. Following December the monthly rate of increase lessened for Dwarf and Giant Cavendish and was reversed temporarily for Tui. The obvious advantage of the Giant Cavendish in the early part of the trial appears to have lessened although it is still relatively high.

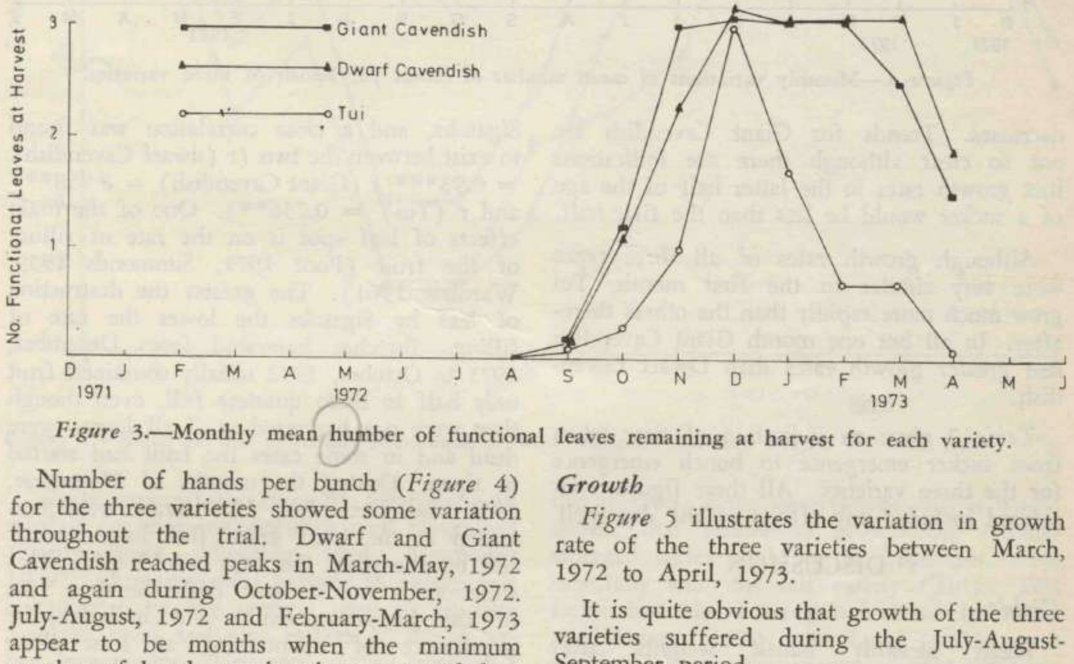


*Figure* 3.—Monthly mean number of functional leaves remaining at harvest for each variety.

Number of hands per bunch (*Figure* 4) for the three varieties showed some variation throughout the trial. Dwarf and Giant Cavendish reached peaks in March-May, 1972 and again during October-November, 1972. July-August, 1972 and February-March, 1973 appear to be months when the minimum number of hands per bunch was recorded.

Although Giant Cavendish in most months had the greatest mean number of hands per bunch, there would appear to be little difference between this variety, and the dwarf. Tui on the other hand had a fairly constant low number up to August after which a peak was reached in November followed by a drop as with the other two varieties.

*Growth*

*Figure* 5 illustrates the variation in growth rate of the three varieties between March, 1972 to April, 1973.

It is quite obvious that growth of the three varieties suffered during the July-August-September period.

Growth rates during the latter months of the trial are lower than the preceding month's figures.

*Figure* 6 suggests that there is considerable variation in growth rate as the suckers age. Initial growth for Tui and Dwarf Cavendish appears to be somewhat depressed but increases to a maximum at 3-4 months and then

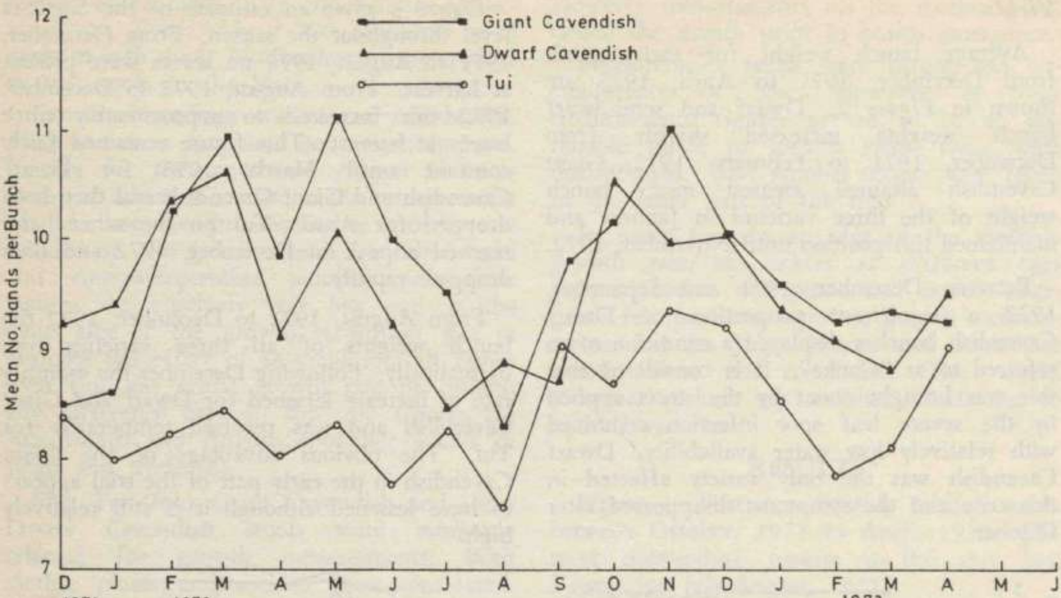


*Figure* 4.—Monthly variations of mean number of hands per bunch of three varieties.

decreases. Trends for Giant Cavendish are not so clear although there are indications that growth rates in the latter half of the age of a sucker would be less than the first half.

Although growth rates of all three types were very similar in the first month, Tui grew much more rapidly than the others thereafter. In all but one month Giant Cavendish had greater growth rates than Dwarf Cavendish.

*Table* 2 gives an indication of time taken from sucker emergence to bunch emergence for the three varieties. All these figures considered included any effects of the dry spell.

## DISCUSSION

### *Yields*

Mean monthly bunch weights after February, 1972 are closely related to the number of functional leaves not killed by Sigatoka, and a close correlation was found to exist between the two (r (dwarf Cavendish) = 0.93***, r (Giant Cavendish) = 0.858*** and r (Tui) = 0.736**). One of the main effects of leaf spot is on the rate of filling of the fruit (Pont 1971, Simmonds 1959, Wardlaw 1961). The greater the destruction of leaf by Sigatoka the lower the rate of filling. Bunches harvested from December, 1971 to October, 1972 usually contained fruit only half to three quarters full, even though they were not harvested until all leaves were dead and in some cases the fruit had started to ripen. During the months of November, 1972 and December, 1972 fruit were harvested at the hard green full stage and if left on the plant the fruit would split. This situation is much more desirable than that of the previous months and indicates the importance of maintaining at least three leaves at harvest as has been found by other workers (Turner 1970 and Firman 1970).

*Table* 2.—Mean length of time (months) from sucker emergence to bunch emergence for three varieties

| Tui | difference | Giant Cavendish | difference | Dwarf Cavendish |
|---|---|---|---|---|
| 13.2 | P = .05 | 11.4 | P = .001 | 9.5 |

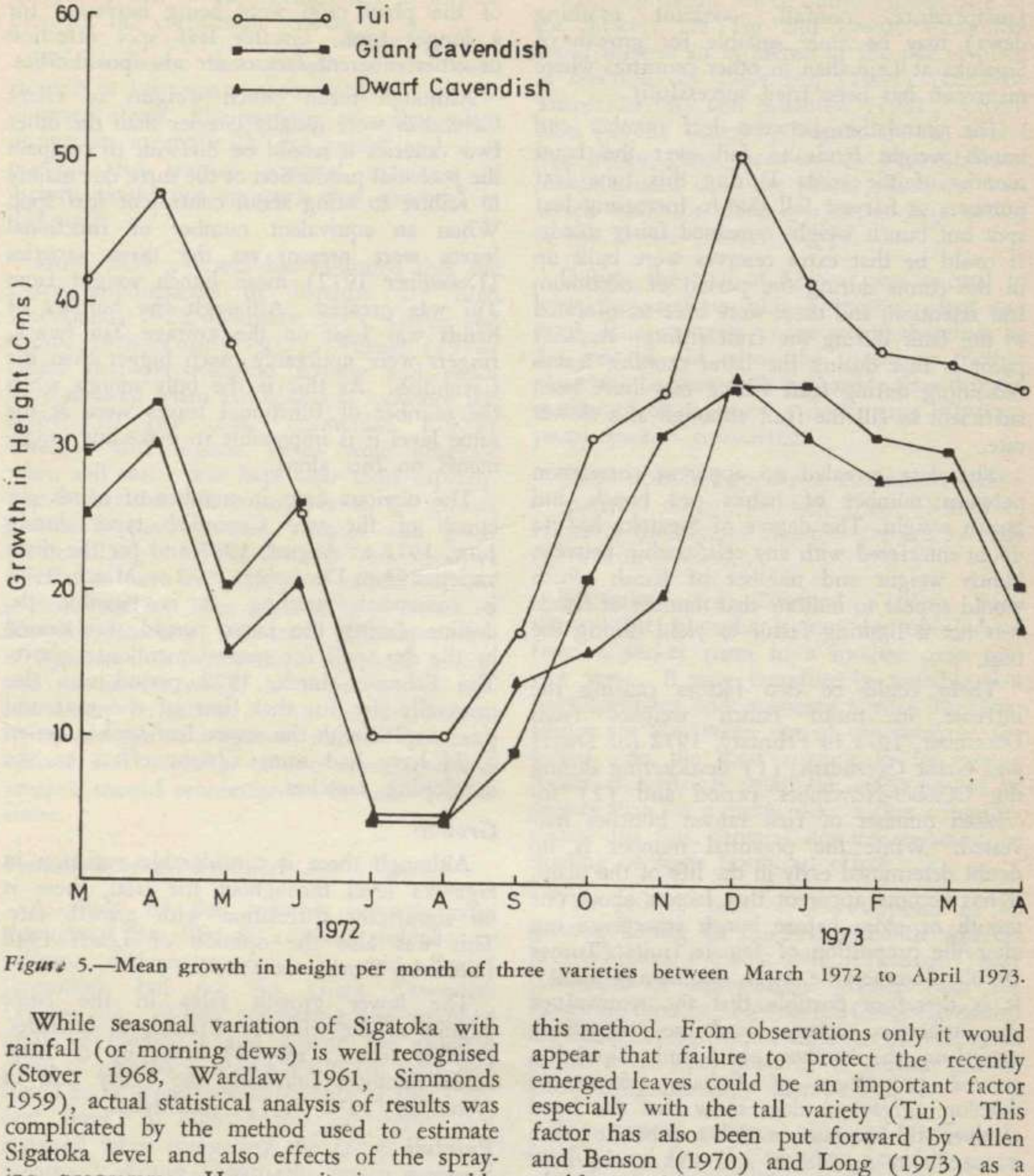


*Figure* 5.—Mean growth in height per month of three varieties between March 1972 to April 1973.

While seasonal variation of Sigatoka with rainfall (or morning dews) is well recognised (Stover 1968, Wardlaw 1961, Simmonds 1959), actual statistical analysis of results was complicated by the method used to estimate Sigatoka level and also effects of the spraying programme. However it is reasonably obvious that the dry period did decrease the level of the disease and the following wet months increased its spread.

Although the mancozeb-white oil water mixture applied with low volume misters has been used successfully overseas (Pont 1971, Broderick and Kuhne 1971), it appears that proper control was not achieved at Lejo using this method. From observations only it would appear that failure to protect the recently emerged leaves could be an important factor especially with the tall variety (Tui). This factor has also been put forward by Allen and Benson (1970) and Long (1973) as a problem with shoulder mounted misting machines in bananas. Spraying at closer intervals may have produced better control during the wet season. The interval between production of new young leaves was then approximately a week (unpublished data) so that during the week when spraying did not occur at least one leaf per plant would have been subject to infection until the next application of spray. Another factor is that conditions (temperature, rainfall, constant morning dews) may be more suitable for growth of Sigatoka at Lejo than in other countries where mancozeb has been tried successfully.

The correlation between leaf number and bunch weight tends to fail over the latter months of the trial. During this time leaf numbers at harvest fell due to increasing leaf spot but bunch weight remained fairly steady. It could be that extra reserves were built up in the corms during the period of maximum leaf retention, and these were later translocated to the fruit during the fruit filling. Another point is that during the latter months, leaves remaining during fruit filling may have been sufficient to fill the fruit although at a slower rate.

The data revealed no apparent correlation between number of hands per bunch and bunch weight. The degree of Sigatoka has no doubt interfered with any relationship between bunch weight and number of hands which would appear to indicate that number of hands was not a limiting factor to yield during the trial.

There could be two factors causing the increase in mean bunch weights from December, 1971 to February, 1972 for Dwarf and Giant Cavendish, (1) desuckering during the October-November period and (2) increased number of first ratoon bunches harvested. While the potential number is no doubt determined early in the life of the plant, it has become apparent that factors about one month or more before bunch emergence can alter the proportion of female fruits (Turner 1970b, Summerville 1944, Simmonds 1959). It is therefore possible that the removal of the numerous suckers eased the competitive strain on the mother plant and allowed a greater proportion of female flowers to develop. *Figure* 2 does show that the hand number did increase from December to reach a maximum in March and this could have caused some increase in bunch weight. The other reason is due to the many observations that the first ratoon crop usually produces bigger and heavier bunches than the plant crop at wide spacing (author's own observations, Simmonds 1959, Turner 1970b). Tui on the other hand has shown a slower response to the above factors. This could be related to its having a longer growth cycle than either of the Cavendish varieties so that bunches of the plant crop were being harvested for a longer time. Greater leaf spot infection or other inherent factors are also possibilities.

Although mean bunch weights of Giant Cavendish were usually heavier than the other two varieties it would be difficult to compare the potential production of the three due mainly to failure to bring about control of leaf spot. When an equivalent number of functional leaves were present on the three varieties (December 1972) mean bunch weight from Tui was greatest. Although the number of hands was least on the average Tui bunch, fingers were noticeably much bigger than the Cavendish. As this is the only month when the number of functional leaves were at the same level it is impossible to make any judgements on this alone.

The obvious drop in number of hands per bunch of the two Cavendish types during June, 1972 to August, 1972 and for the three varieties from December, 1972 to March, 1973 is somewhat puzzling. It is possible the decline during the latter period was caused by the dry spell for reasons mentioned above. The February-March, 1972 period was also unusually dry for that time of the year and this coupled with the severe leaf spot infection could have had some adverse effect on the developing bunches.

### *Growth*

Although there is considerable variation in Sigatoka level throughout the trial, there is no significant correlation with growth rate. This was also the opinion of Leach 1946 (cited by Simmonds 1959).

The lower growth rates in the latter months of the trial are difficult to interpret. Possible reasons are (1) build up of nematode numbers following the heavy rain in December, 1972, or (2) nutritional.

### *Rainfall*

There was a good correlation between rainfall and growth for the ten months March, 1972 to December, 1972 inclusive (r (Tui) = 0.89***, f (Giant Cavendish) = 0.78**, r (Dwarf Cavendish) = 0.89***). Monthly rainfall figures as indicated in *Figure* 1 were adjusted so as to give an accurate figure for rainfall between actual times growth recordings were made. After December soil moisture was most likely not the limiting factor to growth and it was decided not to include these in the correlation studies.

This indicates that growth of the three varieties at Lejo was very susceptible to periods of water stress. Figures were of course taken during an exceptionally dry period and it is possible that normal seasonal reduction in growth would not approach that observed in this trial.

Much work overseas has indicated that the water requirements of bananas are high (Simmonds 1972, Wardlaw 1961, Green and Kuhne 1970, Turner 1972). Turner (1972) found that physiological activity and yields were reduced when available soil moisture fell below 70 per cent. Trachoulas (1971) observed that highest yields were obtained when soil water was kept near field capacity. The higher the soil moisture level, the greater the hand number, fruit number and grade (fruit filling) of the bunch. Any positive correlation between yield and rainfall in the present trial has been masked by presence of Sigatoka. However, with more efficient control of Sigatoka it is highly likely that both growth and production would be improved by supplementary irrigation during the dry season. In the absence of irrigation, removal of young suckers and slashing of the cover crop, if present, should economize on use of available water.

### *Variation of growth with age of plant*

A study of the monthly growth rates throughout the life of a plant yielded significant differences for Tui and Dwarf Cavendish, but not for Giant Cavendish (*Figure* 6). When comparing the grouped mean of months 1 and 2 with the grouped mean of months 3, 4 and 5 for Tui there was found to be significant difference at the 5 per cent level. A high degree of significance occurred when comparing the group mean of months 3, 4 and 5 with the group mean of months 6, 7, 8, 9, 10 and 11 ($P = .01$).

The growth rate of the first month of Dwarf Cavendish was found to be significantly different ($P = 0.05$) than the group mean of months 2, 3 and 4. When considering the group mean of months 2, 3 and 4 with the group mean of months 5, 6 and 7 there is a high degree of significance ($P = 0.01$).

The significant lower initial growth rate of the suckers for Tui and Dwarf Cavendish could suggest an influence of the parent plant as described by Champion (1963) (cited by Turner 1970b) and Wardlaw (1961). Champion (1963) (cited by Turner 1970b) found that in the giant varieties this parental dominance existed until the parent plant was harvested while the effect was not so long lasting in the Dwarf Cavendish type.

During the trial at Lejo it was normal to leave two suckers plus a mother plant per stool. The youngest sucker would therefore be 2-4 months old when the parent or mother plant was harvested. It is possible then that the mother plant did exert a dominating effect on young suckers considered.

There does not appear to be much evidence of parental dominance with Giant Cavendish. However the figures obtained are too variable for a true assessment.

Walmsley and Twyford (1968) have shown that phosphorus can be translocated from a sucker corm to a mother corm and vice versa. It may therefore be possible that photosynthates and nutrients needed for fruit filling are also taken out of the corm of the sucker. As the total amount in the young sucker is relatively small the effect would be greater than on a much older sucker. Another reason for this parental dominance could be shading or some hormonal effect.

The growth rate of Tui appears to be greatest during its third-fifth month whereas growth during the first four months of Dwarf Cavendish is significantly greater than the following months. Figures for Giant Cavendish are again not significant although there appears to be a tendency towards a greater growth rate during the early months.

The growth patterns produced particularly for Tui and Dwarf Cavendish generally agree with the findings of other workers (Simmonds 1959, Turner 1970b). They also indicate the importance of the early months of a banana stem. It is generally accepted that fertilizers applied in the latter part of the life of a single stem will not be utilized to the same extent as if applied in the early phase (Summerville 1944, Simmonds 1959).

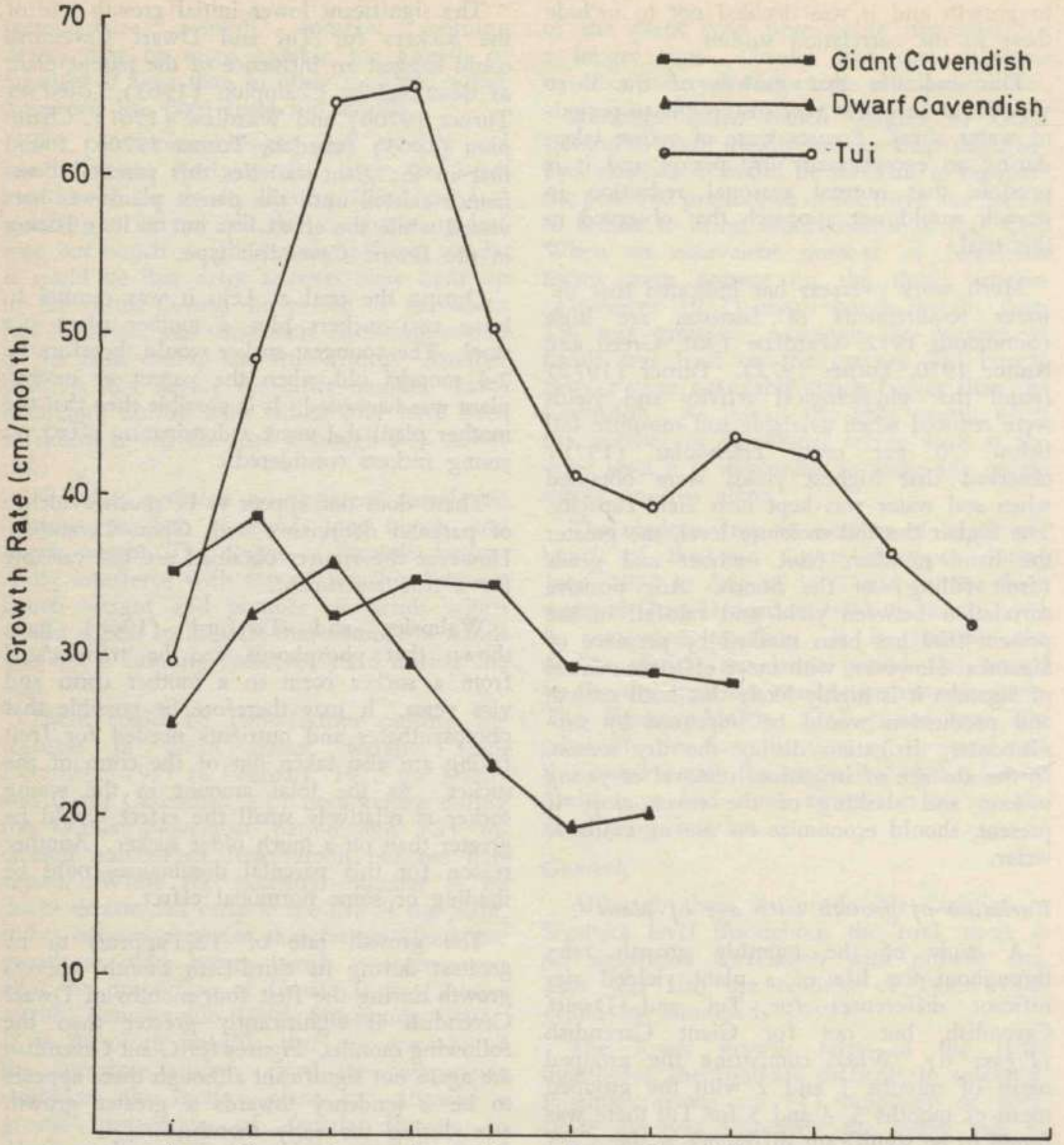


*Figure 6.*—Variation of growth rate with age of stem under no water stress.

***Sucker emergence—bunch emergence***

Figures indicate that as the variety gets taller, it takes longer to throw a bunch. This would indicate a decisive advantage for the shorter varieties in a commercial situation. It must be remembered than the figures taken in this trial were taken over a period which included a drought and severe leaf spot infection. Time at which the drought affected the plants' growth did not appear to significantly alter the length of time taken to bunch emergence although it is highly possible that the dry spell did in fact lengthen this time. Actual times may vary from year to year depending on a range of factors.

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REFERENCES

ALLEN, R. N. AND BENSON, R. J. (1970). Controlling leaf diseases of bananas. *Agric. Gaz. N.S.W.*, 81:558-563.

BRODERICK, H. T. AND KUHNE, F. A. (1971). Sigatoka in bananas can be profitably controlled. *Farming in South Africa*, 7:22-23.

FIRMAN, I. D. (1971). Crop Protection Problems of Bananas in Fiji. PANS, 16(4):625-631.

GREEN, G. C. AND KUHNE, F. A. (1970). The response of banana foliar growth to widely fluctuating air temperatures. *Agric. Sci. S. Africa Agroplantae* 2, 3:105-107.

LONG, P. G. (1973). Control of banana black leaf streak disease in Western Samoa. *Trop. Agric.* (Trinidad), 50(1):75-84.

PONT, W. (1971). Control of Banana Leaf Diseases. *Qld. Agric. Journal*, 96(10):709.

SIMMONDS, N. W. (1959). *Bananas* (Longmans: London).

SLATYER, R. O. (1964). Climate of Buna-Kokoda Area. Lands of Buna-Kokoda area Territory of Papua New Guinea. C.S.I.R.O. (Aust.) Land Research Series No. 10, 45-53.

STOVER, R. H. (1968). Leaf spot of bananas caused by mycosphaerella musicola. Perithecia production and sparodochia production in different climates. *Trop. Agric.*, 45(1):1-11.

SUMMERVILLE, W. A. T. (1944). Studies on nutrition as qualified by development in *Musa cavendishii. Qld. J. agric. sci.*, 1:1-127.

TROCHOULIAS, T. (1971). Sprinkler Irrigation of bananas. *Agric. Gaz. N.S.W.*, 82(1):55.

TURNER, D. W. (1970a). Bunch covers, leaf number and yield of bananas. *Aust. Journal of Experimental Agriculture and Animal Husbandry*, 10:802-805.

TURNER, D. W. (1970b). Growth of the banana. *Journal Aust. Inst. agric. Science*, 36(2):102-110.

TURNER, D. W. (1971). Effects of climate on rate of banana leaf production. *Trop. Agric.* (Trinidad), 4(3):283-287.

TURNER, D. W. (1972). Banana Plant Growth. Dry matter, production, leaf area and growth analysis. *Aust. Journal of Experimental Agriculture and Animal Husbandry*, 12(55):216-

WALMSLEY, D. AND TWYFORD, I. T. (1968). The translocation of phosphorus within the stool of Robusta bananas. *Tropical Agriculture*, 45:229-233.

WARDLAW, C. W. (1961). *Banana Diseases.* Longmans (London).

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# BUNCH COVERS FOR BANANAS IN THE NORTHERN DISTRICT

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### ABSTRACT

*The effects of blue polyethylene bunch covers on Dwarf Cavendish and Giant Cavendish bananas were observed at Lejo Experimental Station in the Northern District over a period of seven months.*

*Covers consistently reduced the time between bunch emergence and bunch harvest for both Dwarf Cavendish and Giant Cavendish over the period of the trial. The reduction in time ranged from* 4.3 *days to* 14.0 *days.*

*The skin of fruit from covered bunches was significantly softer than that from uncovered bunches. There was only slight indication that yields of Dwarf Cavendish will be increased by using this type of cover, although figures were difficult to interpret due to inherent and monthly variations in Sigatoka severity.*

*Covered fruit in general were much more attractive, being free of skin blemishes caused by either insects, fungi, birds, and the abrasive action of leaves or spray*

*Covers were also very effective in protection against banana fruit fly* (Strumeta musae) *infection. However regular inspections had to be made for damage to the cover by insects such as long horned crickets (unknown species of Family Gryllacrididae).*

*Sunburning was also a problem and measures had to be taken to protect the top hands particularly when leaf canopy was reduced by Sigatoka leaf disease.*

## INTRODUCTION

Bunch covers for bananas were first used in parts of Eastern Australia during the winter months. Berril (1956) reported that bagging of bunches with hessian gave protection against chilling, sunburn and blemishes caused by windblown dust, birds, and the abrasive action of dead leaves. Berril (1956) also found that with plastic covers, bunch weight was increased by 10 per cent and that this was due to increased weight of individual fingers.

The advantage of increased yield with plastic bunch covers has also been noted by other workers (Rippon and Turner 1970, Cann 1965, Sampaio and Simao 1970). In New South Wales increases of up to 25 per cent were observed by Cann (1965) when covers were used during the winter, while Rippon and Turner (1970) found that blue polyethylene covers increased yields by 22 per cent when used during the spring-summer months.

Some workers have observed that covered bunches can be harvested earlier than uncovered bunches. Turner (1970) states that in commercial plantations in New South Wales covered bunches mature and are cut two to three weeks before uncovered fruit. Perumal and Adam (1968) found that bagging of Giant Cavendish bunches reduced the time to harvest by eight days when using perforated plastic bags and by 16 days if kraft paper bags were used.

Skin softness was another factor which was noted by Berril (1956) to change with the use of bunch covers. On the other hand Rippon and Turner (1970) found no difference in skin softness when using blue polyethylene sleeves applied during the summer in New South Wales.

Considering the beneficial effects reported from using bunch covers and also their role in preventing banana fruit fly (*Strumeta musae*) infection, it was decided to set up a trial to observe the effects of blue polyethylene covers on Cavendish bananas at Lejo Experiment Station in the Northern District.

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## MATERIAL AND METHODS

### *Plants*

Dwarf Cavendish and Giant Cavendish plants were selected at random from a mixed block, approximately 2/3 hectare in size and covers applied over a period of five months beginning in September 1972. The stools were approximately three years old and severely infected with Sigatoka leaf disease (*Cercospora musae*). Attempts to control the disease with fortnightly applications of mancozeb/white oil mixture were found to be only partly successful. The bananas were planted on a 3.6 × 3.6 metre spacing on a volcanic ash sandy loam soil.

Due to the variation in level of Sigatoka infection throughout the trial and to a drought during mid 1972, bunch weights and times for bunch maturity varied considerably from month to month and complicated interpretation of results.

Bunches were harvested when the fingers were round and full.

Yield figures for Giant Cavendish were not taken due to the relatively small number of this variety with bunch covers and the variability existing between stools.

### *Covers*

Blue polyethylene sleeve covers were applied to bunches 1-2 weeks after emergence. It was found necessary to wait until bracts had dried or partially dried so that they could be easily removed before applying the cover. If bracts were retained inside the cover, staining of the fruit usually resulted. To complete the protection against banana fruit fly (*Strumeta musae*) covers were tied off under the bunch leaving a small channel to drain condensed liquid from inside the cover. This was done about two weeks after the covers were applied and bunches had fully elongated. Bells were removed.

Sunburning especially of the top two hands was a problem and this was only partially offset by inserting the flag leaf inside the cover. Generally speaking the greater the Sigatoka infection the greater the incidence of sunburn.

Another problem which arose with the covers was the damage caused by the long horned cricket (unknown species of Family Gryllacrididae) which chewed holes through the cover. As holes were noticed they were patched up.

### *Skin Softness*

Skin softness was measured by the amount of pressure which had to be applied to a 3-inch nail in order for it to break through the skin. The nail was attached to the end of a length of pine (30 cm long) which was pivoted in the middle of its length. Pressure was applied at the other end by a 100 gm spring balance. The same equipment was used for all measurements taken over the December-March period. The end of the nail was cleaned after each set of readings to avoid possible corrosion.

Three fingers were randomly chosen from each bunch immediately after harvest. Only firm green fingers were used and obvious soft spots and other forms of skin blemishes avoided. At least twenty sites were chosen on each finger and the readings averaged out. The average of the three fingers was then found, to give a reading for the bunch. Eight bunches from each treatment were sampled in this way.

## RESULTS AND DISCUSSION

*Figure* 1 (p. h) illustrates the monthly rainfall variation throughout the trial. As the block was not irrigated during the dry months of July-August-September 1972 reductions in growth rate occurred (Heenan, unpublished data 1973).

### *Bunch Emergence—Harvest*

*Table* 1 indicates that bunch covers do have an effect on decreasing the time required for bunch maturity by an average of eight days.

An analysis of variance showed that the effect of bunch covers was very highly significant and that there was no significant difference between varieties or between months of maturity in the response to bunch covers.

The results in general agree with the findings of other workers (Perumal and Adam 1968, Turner 1970, Berril 1956) who found that bunch covers accelerate development of bananas by about a week.

The decreasing time for maturity from December, 1972 to April, 1973 (*Table* 1)

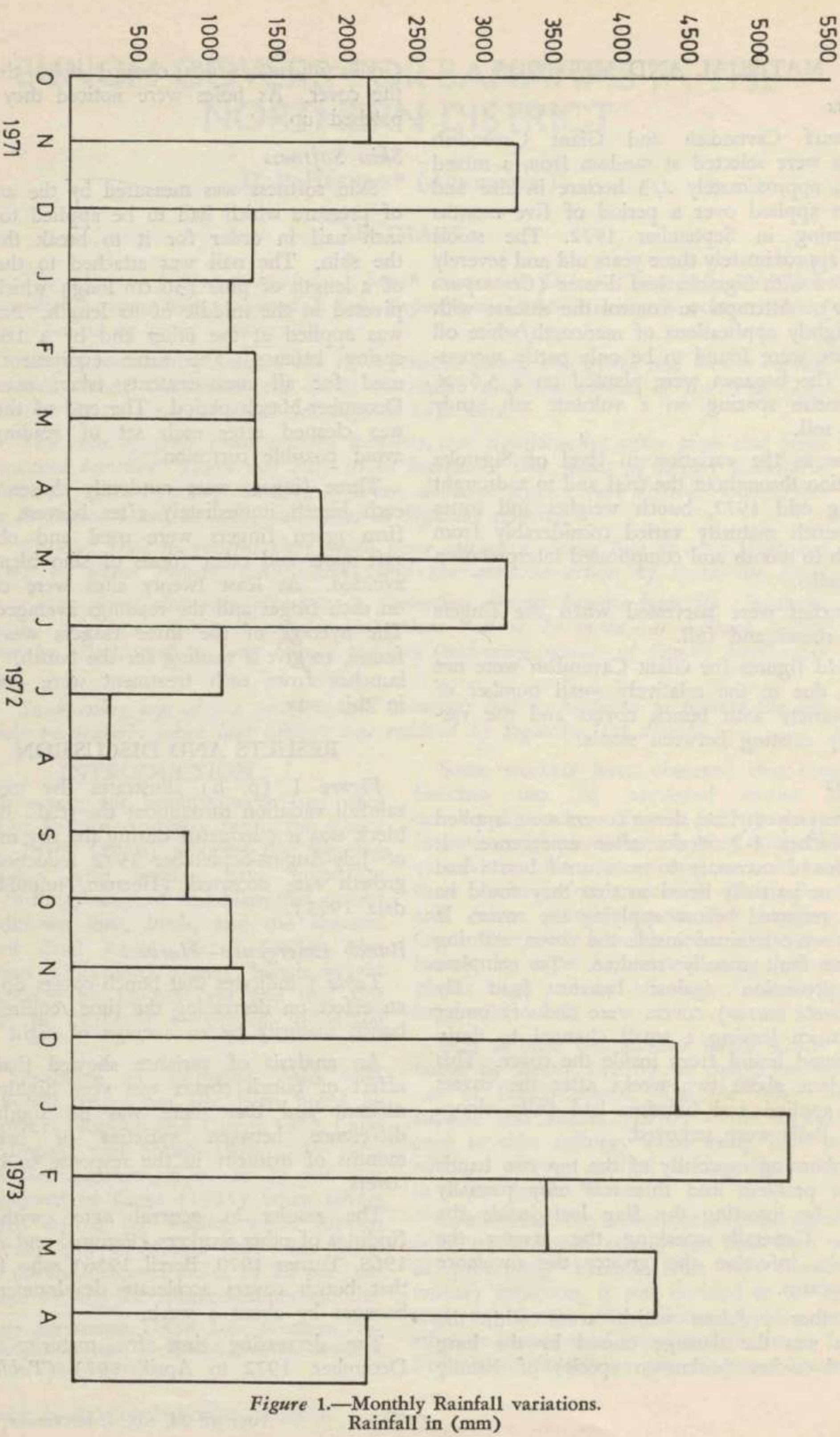


*Figure* 1.—Monthly Rainfall variations.
Rainfall in (mm)

could be due to indirect effects of the drought during 1972 (*Figure* 1). Periods of water stress are reported to reduce physiological activity of bananas (Turner 1972). It is therefore quite possible that the dry period could have influenced physiological activity of the young bunches at that time thus delaying their development and resulting in longer times to reach harvest. Bunches harvested in the latter part of the trial would have been less influenced by this dry spell.

### *Yields*

Average weights of bunches harvested, classified according to numbers of hands per bunch and time of harvest, are summarized in *Table* 2. There were variable numbers of bunches in each class.

*Table* 1.—**Effect of bagging of Dwarf Cavendish and Giant Cavendish bunches on the number of days from bunch emergence to harvest**

| Month of harvest | Time interval (days) between bunch emergence and harvest | | | |
|---|---|---|---|---|
| | Dwarf Cavendish | | Giant Cavendish | |
| | Uncovered | Covered | Uncovered | Covered |
| December | 110 | 102.5 | 109.8 | 105.5 |
| January | 104 | 92.6 | 103.8 | 95 |
| February | 98 | 91 | 101.8 | 88 |
| March | 97.3 | 83.3 | 90.5 | 82 |
| April | 89.3 | 82.4 | 90.3 | 86.3 |

*Table* 2.—**Effect of covers on the weight of Dwarf Cavendish bunches of varying size**

| | Bunch Wt. (Kgms) | | | | | |
|---|---|---|---|---|---|---|
| | − Bunch Cover | | | + Bunch Cover | | |
| | 9 hands | 10 hands | 11 hands | 9 hands | 10 hands | 11 hands |
| Dec.-Jan. | 21.9 | 23.9 | 25 | 25.85 | 26.75 | 32.3 |
| Mar.-April | 27.1 | 27.2 | 33.5 | 26.1 | 29.75 | 31.3 |
| May-June | 21.8 | 24.8 | 25.5 | 25.2 | 24.1 | |

Analysis of variance showed a significant increase in weight of covered bunches but the weighted mean increase was only 1.8 kg per bunch. There was some visual evidence that individual fingers from covered bunches were fuller than fingers from uncovered bunches.

It appears that the effect of covers on bunch weights may be small in the inner tropics. Although Rippon and Turner (1970) observed increases of 22 per cent during the spring-summer months in New South Wales, Sampaio and Simao (1970) recorded non significant increases of only 1.37 kg per bunch on Dwarf Cavendish bananas in Brazil. The type of cover used was blue polyethylene in both cases. An increase of 10 per cent was recorded by Berril (1956) in southern Queensland using plastic sleeve covers. However this was found during the winter months. It is highly likely that lower temperatures (and humidities) were reached during the trial conducted by Rippon and Turner (1970) than at Lejo.

### *Skin Softness*

Bunch covers significantly softened the skin of both Dwarf Cavendish and Giant Cavendish. The effect of the cover on the skin appears to be more pronounced with Giant Cavendish, reducing the amount of pressure required to break the skin by 162.8 gm or 31 per cent. The reduction obtained for Dwarf Cavendish was 69.2 gm or 18.3 per cent.

The results obtained agree with those obtained by Berril (1956) but not by Turner (1970). Turner used a similar type of cover to those used in the present trial but his method of determining skin softness is not known and no figures were given.

*Table* 3.—Effect of bunch covers on skin tenderness as measured by the pressure (in grams) which has to be applied to force a 3" nail through the skin of Dwarf Cavendish and Giant Cavendish bananas

| Variety | Pressure (gms) | |
|---|---|---|
| | − Bunch Cover | + Bunch Cover |
| Dwarf Cavendish | 376.9 | 307.7* |
| Giant Cavendish | 520 | 357.39** |

* Significant at P= .01
** Significant at P= .001

The economic importance of this reduction in skin toughness would become most apparent during transport of the bananas. Covered bunches would not only be more susceptible to bruising but also to sunburn. Berril (1956) recommends that it is best to leave the cover on after harvest and bring the bunch under a shed. The cover can then be removed after twenty-four hours. The author's own observations in the field indicated that fruit were more susceptible to sunburn than uncovered fruit, after the covers had been removed.

The apparent difference between varieties was significant at the 1 per cent level indicating that fruit skin of Giant Cavendish is harder to penetrate than skin of Dwarf Cavendish fruit.

### *Other Observations*

External appearance of covered fruit was in general more attractive than uncovered fruit. The skin was usually a clearer golden green colour free of any marks from insects, disease or abrasive action of dead leaves.

It was noted that the later the stage of application of the cover the greater was the damage by russeting agents causing brownish discolourations on the skin. This was also the opinion of Lachenaud (1972) who found that covers were best applied at a very early date (lifting of first bract) to control banana rust thrip (*Chaelanaphathrips orchedii*)

Covers appeared to have little effect on taste or eveness of ripening.

Sunburn effects were in some cases severe particularly where Sigatoka leaf spot had largely reduced the number of leaves, leaving the bunches exposed. The topmost hands were usually the only ones affected. Sunburn was reduced to a certain degree by folding the last emerged leaf inside the cover and over the top hands. A single sheet of newspaper was tried by Turner (1970) who reported not only partial protection from sunburn but further increases in yield.

Complete fruit fly control was obtained when bunch covers were tied off at the bottom leaving a small hole to drain condensed liquid. Although sleeve covers resulted in some reduction in infection they could not be regarded as a commercial form of control of fruit fly unless the bottom is secured.

## CONCLUSION

Results indicate that bunch covers do decrease the time required for bunches to mature, soften the fruit skin and develop a more "attractive" looking fruit. Increases in bunch weight were significant in only one case and overall results were too variable to form a true picture of the effects of bunch covers on yields.

Reasons for the changes brought about by the bunch covers are not clear. The warmer air trapped inside the bag could play a major role in decreasing the time required for bunch maturity as suggested by Perumal and Adam (1968). The high humidity as well as the high temperatures developed inside the bags would no doubt have affected the tenderness of the skin. It is possible that perforated covers will reduce softening of the skin by reducing the high humidity inside the cover.

The physical protection against banana fruit fly and other agents causing fruit blemishes was effected as long as the cover was complete. Damage by the long horned crickets can be quite extensive and would require some form of control and continual checking of the covers.

Blue polyethylene covers secured at the bottom of the bunch do impose some inconvenience in determining the state of maturity of the fruit for harvest and covered bunches require a closer inspection than uncovered bunches.

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## REFERENCES

BERRIL, F. N. (1956). Bunch covers for bananas. *Qld. agric. J.*, 82:435-9.

CANN, H. J. (1965). Banana growing—plantation practices. *The Agric. Gaz.* N.S.W., 76:672.

LACHENAUD, J. L. (1972). Protection centre le thrips de la rouille par gamage du regime de bananas. *Fruits*, France, 27(1):17-19.

PERUMAL, A. AND ADAM, A. V. (1968). Bagging of Giant Cavendish Banana Stems in Honduras. 1—Effect on number of days from flower emergence to fruit harvest. *Trop. Agric.*, Trinidad, 45 (2):109-112.

RIPPON, L. E. AND TURNER, E. W. (1970). Summer bunch covers for bananas. *Agric. Gaz.* N.S.W., 81(6):344-45.

SAMPAIO, V. R. AND SUMAO, S. (1970). Banana-packing of the bunches in bags immediately after flowering. *Rev. Agricultura Brazil*, 45:75-77.

TURNER, D. W. (1970). Bunch covers, leaf number and yield of bananas. *Aust. J. Expt. agric. and Animal Husbandry*, 10:802-805.

TURNER, D. W. (1972). Banana Plant Growth. Dry matter production leaf area and growth analysis. *Aust. J. Expt. agric. and Animal Husbandry*, 12(55):216.

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