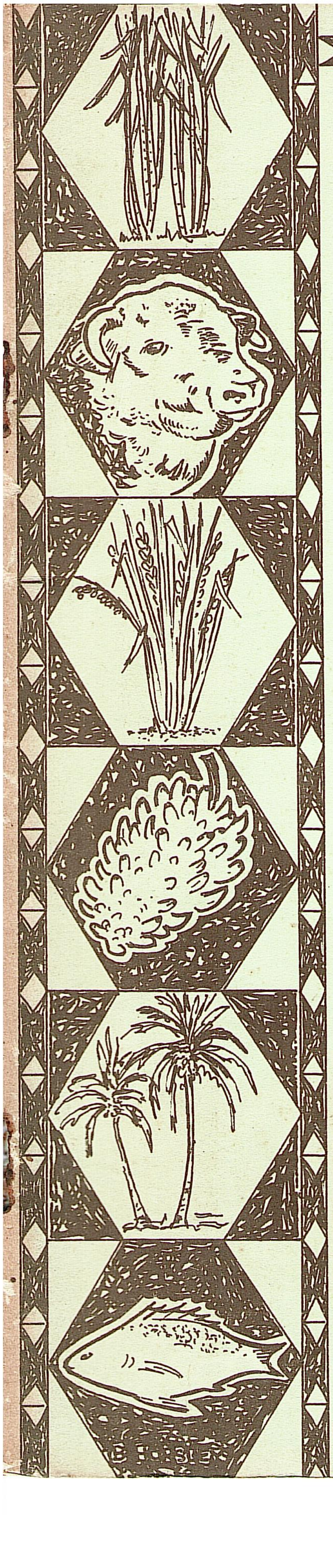

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JAN. - JUNE 1972

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Fiji Agricultural Journal

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CONTENTS :—

			PAGE
A. J. VERNON	:	Metrication	1
R. I. LEATHER	:	Coconut Research in Fiji	3
D. R. SINGH	:	The Effects of Drenching and Rotational Grazing on Gastro-Intestinal Parasites in Sheep	11
P. SIVAN, A. J. VERNON, C. PRASAD	:	Dalo (Taro) Spacing Trials 1971	15
S. CHANDRA	:	Agriculture, Land Use, and Smallholder Farming Problems in the Sigatoka Valley	21
N. P. PATEL	:	Rice Research in Fiji 1960 - 1970 — Part III Weed Control	27
M. L. GORMAN	:	The Origin of the Avifauna of Urban and Suburban Suva, Fiji	35
H. K. McINTYRE, K. REDDY	:	The Effects of Diet and Stocking Rate on Broiler Chicken Growth	39

METRIC CONVERSION FACTORS

A	B	To convert A to B multiply by	To convert B to A multiply by
inches (in)	centimetres (cm)	2.54	0.394
feet (ft)	metres (m)	0.305	3.28
yards (yd)	metres	0.914	1.09
chains	metres	20.1	*
chains	kilometres (km)	0.0201	49.8
miles	kilometres	1.609	0.621
ounces (oz)	grams (g)	28.35	0.035
pounds (lb)	grams	454	*
pounds	kilograms (kg)	0.454	2.205
hundred-weights (cwt)	kilograms	50.8	*
tons	kilograms	1016	*
tons	metric tons (tonnes) (mt)	1.016	0.984
square in (sq in)	square cm (cm^2)	6.45	0.155
square ft (sq ft)	square metres (m^2)	0.0929	10.8
square yd (sq yd)	square metres	0.836	1.196
square chains	square metres	405	*
square chains	hectares (ha)	0.0405	24.7
acres (ac)	hectares	0.405	2.47
square miles	hectares	259	*
square miles	square km (km^2)	2.59	0.386

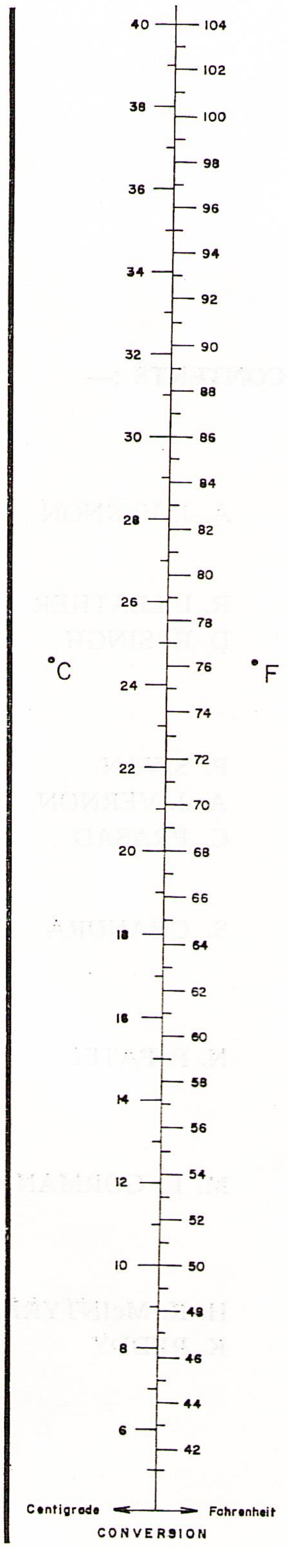
† For practical purposes 1 ml = 1 cubic centimetre.

A	B	To convert A to B multiply by	To convert B to A multiply by
fluid ounces	millilitres (ml) †	28.4	*
pints	litres (l)	0.568	1.76
gallons	litres	4.55	0.22
cubic feet	cubic metres (m^3)	0.0283	35.3
cubic yards	cubic metres	0.765	1.31
lb/ac	kg/ha	1.12	0.89
cwt/ac	kg/ha	125.5	*
ton/ac	mt/ha	2.51	0.398
pint/ac	l/ha	1.40	0.712
gall/ac	l/ha	11.2	0.089

$$°C = 5\,(°F - 32)/9$$

$$°F = [9\,(C)/5] + 32$$

* These factors will seldom be needed.



METRICATION

The Editor

A. J. VERNON

Research Division, Department of Agriculture, Fiji*

This March it was announced that Fiji will change from official use of the Imperial system of weights and measures to the metric system. Some may regret the passing of the Imperial Roman miles (originally 'milium', a thousand double paces) and pounds (from 'pondo librum' the weight of a librum of silver). Others may regret the loss of such quaint medieval additions to the system as the furlong (i.e. a furrow-long the distance an ox can plough before needing a rest) and the acre (a day's work for an ox plough). But agricultural scientists will welcome the change to a system in which plot quantities can be converted to farm scale simply on the basis of 1 g/m^2 equals 10 kg/ha or 100 g/m^2 equals 1 metric ton/ha.

In Britain the agricultural science journals led informed agriculturalists into "thinking metric" by changing in advance of the official, public time-table. This journal will similarly set a lead in Fiji. The public time-table has not yet been announced but, as from our next issue weights and measures in this journal will be given *primarily* in metric units.

Quantities may be given in metric units alone, in metric with Imperial equivalents in brackets, or in Imperial units with or without metric equivalents. The guidelines to authors as to which to use, and the reasons why these distinctions need to be made are as follows.

Metric units with Imperial equivalents bracketed

This will be the immediate general rule, in principle. The Imperial equivalents may often be omitted as provided for under (b) below, and will be omitted with increasing frequency with time as provided for under (c) below; but should not be omitted from specific quantities of practical importance (e.g. recommended rates of application of chemicals) until such time as metric units have become fully accepted. (See also 'Imperial units alone')

Metric units alone

(a) In laboratory and other theoretical studies, as has always been the custom. Insofar as such studies mean anything quantitative to the non-scientists, it is in the *relation* of the quantities to each other (e.g. that x is twice y) not their absolute values. This also applies to some field studies.

(b) When many quantities of the same units are being given in quick succession. The text then becomes very cluttered with parentheses if every quantity is given twice. For example, one paragraph might include many yield figures, to give each of which in both kg/ha and lb/ac would be unduly cumbersome. Tables are the extreme case of many quantities in quick succession, and these will almost invariably be given in one type of unit only.

(c) In time, as this becomes generally acceptable.

Some British journals, in the transition stage, made the rule that if quantities were given in one type of unit only, either in the text or in tables, then the appropriate conversion factor(s) should be given at least once in the paper. In this journal all the necessary conversion factors will be reprinted (as opposite) each month throughout the transition period so there will be no need for this.

Imperial units, with metric bracketed

This will be the general rule when the quantity is, by design, an integral number of Imperial units: for example, a cocoa

*On secondment from Rothamsted Experimental Station.

spacing of 10' x 10'. In a short time such quantities will be rare in current research; but for many years to come we will have permanent-crop research plots whose spacing can be more conveniently described in feet than metres.

Imperial units alone

As described under "metric units alone" dual expression of all quantities is sometimes unduly cumbersome and then, if Imperial units are required to be shown at all (for either of the reasons given above) they may be shown alone, without metric equivalents.

ACCURACY OF CONVERSIONS

There is a danger that those unappreciative of the meaning of figures may use conversion factors to generate unnecessary, even ridiculous, numbers of significant figures. For example the statement that the average copra yield of coconut plantations in Fiji is "about 6 cwt per acre could be converted to "about 753 kg/ha" using the conversion factors now given, or "about 753.312 kg/ha" using those given in (1).

Even without conversion, many of the quantities in most of the papers submitted to this journal are given to an unnecessary, indeed improper, number of significant figures. Rounding off the excess figures is a tedious editorial duty and some escape notice: e.g. the population of Savu Savu given as 1,862 in Table 1 of (2). This statement was, presumably, exactly true on the occasion of some census; but the 'units' digit can never have had any scientific meaning, and it is doubtful whether the 'tens' digit had. To have given the population as 1,900 (or even 2,000) would have served the author's purpose perfectly well.

The most common error is that of giving crop yields in lb/ac (or kg/ha) with a meaningless unit digit instead of rounding-off to the nearest 10. Such rounding is proper if either (a) the original field weighings were correct only to about 1%, not 0.1%, or (b) the experimental S.E. of the figures exceeds 50, or (c) the units digit is agronomically meaningless. Usually all three of these conditions are fulfilled and then it is not merely proper to round off, but improper not to.

When converting, consider what degree of accuracy is required, or is possible in view of the other sources of error, calculate to one more significant figure and then round that off. A final 5 should generally be rounded to the nearest *even* digit (e.g. 75 is rounded to 80, 65 is rounded to 60.) But when a *difference* between two figures is critical (as in experimental treatment comparison) the figures should be so rounded as to preserve the differences to requisite accuracy.

A special problem arises in conversions of recommendations to farmers. These are usually made in convenient round numbers (e.g. 1 cwt fertilizer, or 3 pints herbicide, per acre) and the nearest equally 'round' metric equivalent may be many per cent different. It is desirable then to reconsider the evidence for the recommendation. This may have been extremely slight, and the figure chosen for its convenience rather than for any belief in its exact accuracy. It may be that reconsidering the evidence for a 1 cwt/ac recommendation will lead to one of 100 kg/ha rather than 125 kg/ha, the exact conversion. Similarly whereas the exact conversion of 3 pints/ac is 4.20 lit/ha, a recommendation of 4 or 4.5 lit/ha may be considered better after reviewing the evidence.

Experimental results will usually be recorded and presented metrically, with Imperial equivalents only of figures of direct practical relevance. But pending the re-measurement of long-term trial plots in m^2, and the acquisition of kg field scales, some field experiments will be recorded in Imperial units. Statistical analysis is then best done on the results as recorded, with conversion of treatment means and S.Es. into kg/ha for presentation.

REFERENCES

(1) Fisher, R. A. and Yates, E. (1963) *Statistical Tables. (6th Ed.)* Oliver and Boyd, London.

(2) Owens, D. *Acanthaster planci* starfish in Fiji: survey of incidence and biological studies *Fiji Agric. J.*, **33**, 15-23.

COCONUT RESEARCH IN FIJI

by

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SUMMARY

The status of the coconut industry and previous research are briefly reviewed. Present research consists of agronomic studies, a short-term programme of improved seed production and a long-term breeding programme.

INTRODUCTION

Table 1 shows various statistics of area and production of coconuts in Fiji from 1875. All pre-1962 figures are taken from the review by McPaul (18). Production is given, in the table and throughout this 'Introduction', in 'Copra equivalent', i.e. each figure includes the copra equivalent of any relevant production (for export or local consumption) of nuts used or exported without making copra. Mean yield per unit area will be given as lb/ac or Kg/ha., meaning copra equivalent in each case. Most of the production is exactly known, from export statistics and factory records of local copra processers. The 1968 and 1975 estimates of unrecorded production are from the current 'Development Plan' (9).

McPaul (18) gives the sources, and mentions the unreliability of pre-1950 area estimates. The 1950 areas are from the survey of Harwood (14), and those of 1968 from the Census (10) of that year. The latter are subject to criticism as will be explained.

TABLE 1

COCONUT AREAS AND COPRA PRODUCTION, 1875-1975

Estimated Areas (acres)				Production (Copra Equivalent)			
				Known Production (period means)		Unrecorded Consumption	
Year	Plantations	Groves	Scattered	Tons/Year	Period	Tons	Year
1875	1,250			4,250	1879-1881		
1890	18,500			6,120	1890-1899		
1900	23,000			11,290	1900-1909		
1910	30,000			15,040	1910-1919		
1920	50,000			22,290	1920-1927		
1928	48,000	82,000		26,370	1928-1939		
				24,690	1940-1949		
1950	72,000†	91,000†		35,320	1950-1959		
1962	168,000			32,800	1960-1969		
1968	178,000*		10,000			5,000‡	1969
				48,300‡	1975	7,000‡	1975

†Harwood's survey.
*Census report, may be underestimate.
‡Estimates given in Development Plan 6.
} See text for references.

Rapid expansion of acreage from 1875 to 1920, with production continuing to increase up to 1928, has been followed by a period of relative stagnation (Table 1). The acreage increased substantially following the second world war, but there

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was little replanting of existing plantations, (in 1962 it was estimated that 56% of the plantation acreage was pre-1914 planting) and the decline in yield of the aging, older, plantations balanced the production of these new plantings so that national production was little more in the 1960s than the 1930s.

In 1962 a Subsidy Scheme was initiated (4) and by 1968 the rehabilitation of 113,000 acres of 'communal groves' and the new planting of 66,000 acres had been reported (7) under the scheme. But, as Child (11) has pointed out, these reports are grossly inconsistent with the 1968 Census (10) because these figures total 179,000 acres and do not include any 'plantation' acreage. Also reported under the scheme was the re-planting of 5,500 acres of plantations; but it is common knowledge that the plantation acreage greatly exceeds this. Indeed, as plantation acreage can easily be surveyed, there is no reason to doubt that Harwood's 1950 figure of 72,000 acres was substantially correct, nor is there any reason to believe there has been any appreciable reduction in plantation acreage since. The Subsidy Scheme claims imply, therefore, a total acreage of about 250,000, excluding scattered palms, as compared with the Census finding of 179,000 acres.

Child (11) suggested that this discrepancy was due largely to the notorious mis-reporting of Subsidy Scheme results. On the other hand it has been suggested (personal communications from various Departmental Staff) that the Census substantially underestimated the 'communal grove' acreage (particularly of some smaller islands). In one particular the 1968 Census appears to support the Subsidy Scheme claims. Besides its area survey the Census also gave an assessment of the percentage of palms in three categories: not yet bearing, bearing, and past bearing. The national total breakdown was reported as 40, 56 and 4% respectively. The first of these figures appears to support the Subsidy Scheme claim of 71,500 acres of new (and re-) planting, as this figure is about 40% of the Census reported total acreage.

This Census categorization was by palm *number* not by *area*. In plantation re-planting the old palms may not be cut out until 8 years after the new palms are planted. Communal groves are constantly regenerating from self-sown nuts (18) and if the older palms are drastically thinned (which treatment was part of the Subsidy Scheme re-habilitation) then the situation in these groves may be effectively much as on under-sown plantations. Moreover, the Census account (10) of this categorization said that these figures were not as reliable as the acreage figures; and discussions with leading plantation owners suggest that, as far as their holdings are concerned, the percentage not yet bearing is a serious over-estimate. There is, therefore, considerable doubt as to what acreage of new planting the Census "non-bearing palms" represent.

To summarize, there are reasons (apart from the disagreement with the Subsidy Scheme claims) to suspect that the 1968 Census underestimated the total acreage, but also there are independant reasons to suspect that the Subsidy Scheme claims are overestimates. Probably the true figures are somewhere in between. Possible limits of the different categories would seem to be :-

		ac	ha
Bearing plantations*	—	50- 70,000	(20-28,000)
Bearing communal groves	—	80-115,000	(32-46,000)
Completely new plantings	—	30- 60,000	(12-23,000)
Scattered palms	—	10,000	(4,000)

*Including those recently re-planted.

The Development Plan (9) discussion of this subject accepted the Census report of 40% of non-bearing *palms* as meaning 40% of the Census-reported *acreage* not yet in bearing and hence calculated a national average production of 740 lb/ac (830 Kg/ha) on the basis of a bearing acreage of 114,910. It is apparent from the foregoing discussion that if there are actually 71,500 acres of palms not yet in bearing then (a) at least 10,000 acres must effectively consist of an under-planting of bearing plantations and groves, and (b) the total acreage must be at least 200,000; i.e. the bearing acreage must be at least 140,000. The national average yield per acre, therefore cannot exceed 600 lb/ac (670 Kg/ha) and is probably nearer 500 lb/ac (560 Kg/ha).*

A more serious source of error in the Development Plan forecast is the assumption that "the new areas will start producing in 1971 and by 1975 should be yielding half their potential, i.e. 14,500 tons per annum" (9). As Child (11) pointed out, much of the new planting is on hill slopes above 300 ft, where coconuts do not produce at their best. Such areas on Wainigata Research Station are giving negligible yield 10-12 years after planting. It is unlikely that the new plantings exceed 50,000 acres, their potential yield (under old standards of management) is probably no more than 500 lb/ac i.e. 11,200 tons a year overall, and they are unlikely to reach half this potential, i.e. 5,600 tons a year, by 1976. This will be offset by a further decline in yield from the 30,000 acres of plantation coconuts that are now over 60 years old. Whereas the Development Plan postulated an *increase* in production of 17,000 tons between 1969 and 1975, the production in 1970 was 4,000 tons *below* the 1960-1969 average, and up to September 1971 (after which date a sharp price drop may have been responsible for a further apparent decline in production) was no better than in the same period in 1970.

Clearly the Development Plan target can be approached during the next ten years only by increasing the yield of existing palms. Little can be done for the older palms, but many of the younger ones would benefit from better management, e.g. weed control, sanitation, and the use of fertilizers. The immediate agronomic research effort must be directed to studying these subjects particularly the use of fertilizers. In the long term it is evident that national production could be very greatly increased. Selected varieties grown under good husbandry standards will yield two to three times the present national average yield per acre.

PREVIOUS RESEARCH (TO 1969)

Despite the importance of the crop to Fiji, annually earning $4M. foreign exchange, there has been, as Child (11) pointed out, a striking "paucity of work on the general agronomy of the crop, in contrast to much excellent work on insect pests (16), and on copra (22)". The Index (20) to the Fiji Agricultural Circular (1920-25) and the Journal (1928-51) gives 75 references to coconuts and copra, of which 59 refer to copra and other products, 7 to pests and diseases and 5 are general articles. The four remaining papers refer to studies of dwarf palms.

Red and yellow dwarfs were introduced from Malaysia in 1922 to Mua estate Taveuni. Before then it seems that only indigenous varieties were grown, and there was no other reported introduction until 1961. In 1928 Marechal (17) made a series of reciprocal crosses between the local cross-pollinated Niu Leka dwarf palm, which he incidentally described, and the recently introduced red Malayan dwarf. He also crossed selections of the heavy fruited Rotuman tall variety.

This work was done on Taveuni and the progeny planted at Navuso near Nausori in 1928. Of the 256 hybrids only 212 remained by 1931 and only 80 by 1970. The first Niu Leka x Malayan Dwarf palms reached bearing in just over three years from planting (1). Later reports mention the great variation among the palms in bearing (2) and that the Niu Leka characters predominated (23).

The Rotuma crosses flowered for the first time in 1936 and the first plot of open pollinated progeny from the original Niu Leka x Malayan Dwarf hybrids was planted at Sigatoka Research Station in 1938 (3). There is considerable variation in the stature, the fruit and the petiole colour of these and later gene-

* Calculated on the 1960-69 mean annual production of 32,800 tons rather than the 1969 figure of 33,089 as used in the Development Plan calculations, adding 5,000 tons for unrecorded domestic consumption in each case.

rations planted there and elsewhere. Systematic yield records have not been kept, but at Yandina in the British Solomon Islands a yield of 3660 lb/ac (4100 Kg/ha) in 1969 has been reported (8) for 200 Niu Leka x Malayan Dwarf hybrids imported as seed from Fiji in 1956. These 200 palms were the survivors of a 50% thinning (of the poorer bearers) and replanting operation in 1966. The yield just quoted was said to have been "calculated", presumably on the basis that the bearing palms occupied half the overall area. It could be objected that they may in fact be partially utilizing the space nominally occupied by the re-plants; but even if some allowance is made for this, the yield is still remarkable. In 1961, Karkar and Markham valley tall varieties were introduced from Papua New Guinea. These and selected Rotuman talls were planted at Naduruloulou and Dobuilevu Research Stations.

There is now a substantial acreage of Malayan dwarfs on plantations in Cakaudrove. On fertile soils at the close spacing of 20' (6.1m) square, yields of up to 2130 lb/ac (2390 Kg/ha) are obtained.

A series of demonstration and formal fertilizer trials was undertaken between 1959 and 1964. Palms under five years old responded to an NPK mixture but inconsistent results were obtained from this on old palms at Levukalailai and Tuvumila estates. Substantial but non-significant responses to potash were obtaned at Vunilagi and Maravu estates. At Wainigata and Seaqaqa Research Stations, the growth of young palms was increased by an NPK mixture but nitrogen in the absence of potash tended to retard growth (5). The trials were distcontinued and the period of yield recording was rather short to produce consistent and reliable results.

The only noteworthy reports since 1964 are a review by Mune (19) of chemical weed control, now well established on larger estates, and a survey by Parham (21) of the distribution of the common tall coconut.

THE CURRENT RESEARCH PROGRAMME

Stations and staff

Two graduate research staff (K. Satyabalan assisted by Y. Reddy) are now resident on Wainigata Research Station, working almost exclusively on coconuts. The former's secondment by the Government of India is consecutive to the author's tour of duty. Y. Reddy is a local officer so a continuity in staffing, the lack of which has frustrated much of the earlier work on this crop, has been assured.

The total area of Wainigata Research Station is 288 acres, but much of this is unusably steep hillside and about 25 acres (mostly of valley bottom) is reserved for cocoa experiments. The remaining area is largely taken up by coconut experiments (see below). There is little or no soil of the types considered most suitable for coconuts in Fiji. Much agronomic research can, of course, be located on plantations; indeed manurial trials are best kept off research stations as much as possible. But there is a pressing need for a main station with much more experimentally usable land of suitable soil types.

Nutritional and husbandry survey

The objectives are to relate yield and/or growth of palms with the level of mineral nutrition, the soil type and the husbandry practices particularly weed control. The major emphasis has been on new subsidy plantings or areas of palms scheduled for replanting. This approach is available as a service on request. It involves the detailed study of an area of coconuts at each of a large number of representative sites throughout the main copra producing regions. From October 1969 to August 1971, about 40 sites were inspected, mostly in S.E. Vanua Levu with some work started on Taveuni and in Lau and Lomaiviti; South West Vanua Levu and Natewa together with Taveuni, will receive attention next.

At each site, yield is assessed by nut counts, the husbandry status is noted and samples of soil, foliage and nuts are collected for analysis. The foliar analyses completed for the survey to date reveal, by the criteria of Fremond (13) that most of the new plantings except those on recent soils are deficient in nitrogen: a similar situation has been observed for bearing palms on the nigrescent and latosol types of soil. For other nutrients, young (and old) palms on coastal coralline soils are occasionally found to be low in potassium and magnesium; on the nigrescent and related steepland soils, magnesium is variable and can be deficient; except for a few isolated cases where potassium is deficient the latosolic and related soil from ash, are adequately supplied with these nutrients. Thus, the least common deficiency or shortage of the major nutrients appears up to now to be phosphorus.

It is on the basis of these results that most of the present series of fertilizer trials have been based.

Fertilizer studies

Seventy acres of nursery-selected common tall and Malayan Dwarf (red and yellow) coconuts were planted on the rather infertile nigrescent and related hill soils of Wainigata Research Station in 1960-62. The growth of these has been poor but is typical of new plantings on similar soils in the district and on other islands. As these plantings form the bulk of the new acreage, on the production from which the fulfilment of the Development Plan rests (see introduction), they provide a good subject for manurial experimentation.

Seven half-replicate blocks of a 2N x 2P x 2K confounded factorial experiment were fitted into the available 70 acres, with four 30-palm plots per block. Foliar analysis having suggested that nitrogen is the chief need the rates of sulphate of ammonia, superphosphate, and sulphate of potash are 5, 3 and 2 lb. (2.3, 1.4 and 0.9 Kg) respectively per palm per year, starting late 1970. Further trials of similar aged palms are required to support this one. These are to be obtained outside the Station.

One of the problems in planning large scale off-station trials is not the lack of palms but the difficulty of finding uniform blocks of suitably aged bearing palms. By June 1970, 4 blocks of 8 plots (16 palms per plot) had been brought into experiment on latosols at Vunilage, one such block on corralline sands at that estate, and one on nigrescent soils at Maravu estate.

These trials, and others now being planned, follow on sites that were inspected in the survey and the fertilizer treatments are as suggested by the foliar analysis of the survey. Thus at Vunilagi and Maravou, 35-50 year old talls in each case, the treatments form a 2N x 4K factorial with rates (excluding nil) of (a) sulphate of ammonia and (n) sulphate of potash of (a) 5½ and (b) 2, 4 and 6 lb (2.5; and 0.9; 1.8, and 2.7 Kg) per palm per year. The trials being planned include a 2N x 3P x 2K factorial on new plantings and replantings on Taveuni and a trial including iron and manganese besides the major elements on replants on white sands at Vunilagi.

A series of demonstration fertilizer trials have also begun on subsidy new plantings in Vivili, Nacavanadi, Kubuna and Navonu Sub-Divisions, Vanua Levu. Fertilizer of an appropriate formulation based upon foliar analysis is applied to about 0.7 ac. of palms, with a similar area marked as a control. Ring weeding of palms is undertaken on as many of these sites as is practicable.

Meanwhile, nutrient studies have begun with a small trial (5 replicates of 6-palm plots) on Malayan dwarfs at Wainigata Research Station, appearing on foliar analysis to be deficient in magnesium and nitrogen. A suitable NPK mixture is being applied overall and three magnesium sulphate treatments compared, viz (a) 1 lb (0.45 Kg) thrown into each palm crown (b) the same dose sprayed on with surfactant, and (c) 4 lb (1.8 Kg) per palm applied to the soil.

Cultural experiments

Weed problems are most acute on new plantings, particularly on hill slopes. New planting under the old Subsidy Scheme have been eligible for six annual maintenance payments, but despite this the young palms are often choked by grass. A weed control trial was started on young palms at Wainigata in 1971 with four replications (9 palms per plot) of the 6 treatments :—

1. No weeding.
2. Slashing a 5' (1.5m) radius round each palm every 6 weeks.
3. As (2), but every 12 weeks.

4. As (2), but every 24 weeks.
5. Paraquat; active ingredient, 0.375 lb/ac (0.4 Kg/ha).
6. M.S.M.A.; active ingredient, 3 lb/ac (3.4 Kg/ha).

In many areas herbicide use would be difficult because of the terrain and lack of water. Inter-cropping, as practiced in some areas, seems beneficial; but it is to be expected that leguminous covers would give better results. One area of 10 year old Malayan Dwarf at Wainigata was planted with Pueraria in 1965. Maintenance is now minimal, and a count of 100 sample palms recently gave averages of 28 fronds and 14 nuts per palm, and 12 female flowers per inflorescence compared with corresponding figures of 14 fronds, 1.0 nuts, and 3.6 flowers on a sample 100 palms in surrounding areas without Pueraria. It is planned to follow this with formal experiments.

Under bearing coconuts spraying with 2.4 D amine and/or 2.4.5 T is practised on some of the large estates. There is however, one persistent and resistant weed, namely kaumoce (Cassia tora). Preliminary screening trials using high and low rates of M.S.M.A. Diquat and Paraquat were started in March 1971 on heavily infested areas at Nabeka and Waitavala Estates. Follow up work will be carried out after assessment of the results but to date Paraquat looks the most promising.

Consideration is being given to a spacing experiment. No conclusive experimental results on this topic have yet been reported from anywhere in the world.

Intercropping

Most of the better-run plantations graze cattle under the coconuts, and support mean copra yields of about 800 lb/ac (900 Kg/ha) with a substantial income from the cattle. This intercrop is, indeed, so successful not only in Fiji but also, from my observation, in Ceylon, the Solomons, and the New Hebrides, that it is doubtful whether coconut monoculture will be of much importance in the future. An alternative form of intercropping now finding favour in Malaysia (15) and elsewhere (6) is with underplanted cocoa. This was tried on 350 acres of the Delaiweni estates on Taveuni from 1956 to 1969 with very poor results, due to the use of canker-susceptible cocoa (12). But several owners of small coconut plantations in the Buca Bay area have recently under-planted a few acres with canker-resistant Amelonado cocoa, and initial results are most encouraging.

Both these forms of intercropping, therefore, demand investigation. The cocoa possibility is relatively easily studied, and several experiments are in progress or being planned by the Cocoa Research Section, one of which will involve the yield recording of coconuts with under-grazing compared with coconuts under-planted with cocoa at various spacings. A thorough study of the grazing possibilities is more difficult to arrange. Proposals from the Animal Production Research Section for joint trials involve grazing controls, live weight measurements, and other routines, that could not be secured except on an experimental station. Meanwhile, pending acquisition of coconut research station, consideration is being given to the possibility of organizing some simple off-station trials.

Selection and breeding

A breeding and selection programme was started in 1970. Potential mother palms are being selected within blocks of common tall, Rotuma tall, Niu Leka and Malayan dwarf palms on Taveuni, and within Niu Leka x Malayan dwarf open pollinated hybrids at Sigatoka Research Station. Selected progeny of these will be planted in isolated primary seed gardens, perhaps on Makogai, in 1975: and after further selection there, used to establish district and hybrid seed gardens.

A geneological block of local and overseas varieties (or types) and a variety trial have been planted on Wainigata Research Station. The latter includes: Niu Leka, Rotuman tall, Niu Leka x Malayan dwarf progeny, Karkar tall, common tall, (Taveuni), common tall (Wainigata), F.M.S. tall, Rennel tall, red Malayan dwarf.

A controlled hybridisation programme using local and imported pollen is in progress to produce tall x dwarf, dwarf x dwarf and tall x tall hybrids for long term evaluation and comparison with local selections at various spacings. A total of 136 seednuts from four different tall x Malayan dwarf crosses have so far been harvested.

As a short term measure open pollinated hybrid seed-gardens have been established within existing blocks of tall palms underplanted with Malayan dwarfs on Taveuni. The expected production is 9,000 seednuts in 1971 and 45,000 in 1972. On Wainigata Research Station two fields, one of common tall and the other Malayan dwarf palms, have been interplanted with Malayan dwarf and Rotuma tall seedlings respectively for hybrid seed production from 1976.

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THE EFFECTS OF DRENCHING AND ROTATIONAL GRAZING ON GASTRO-INTESTINAL PARASITES IN SHEEP

by

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SUMMARY

Four groups of lambs were reared from about 3 to 14 months of age at Nawaicoba, two groups set-grazed and two rotationally grazed. One group of each pair received anthelmintic treatment every two weeks, the other was untreated initially. The untreated groups became severely infested with species of *Haemonchus, Bunostomum, Cooperia,* and *Oesophagostomum* and after two months began loosing weight. After five months some had died; the remainder were then drenched, and redrenched two months later, but by the end of the trial were re-infested (*Trichostrongylus spp.* also appearing) and gaining weight at a lower rate than the regularly treated groups.

The untreated group on rotational grazing (involving 30-day intervals between grazing of each paddock) were rather worse infested than the group kept on one paddock throughout.

INTRODUCTION

Since early this century various attempts at commercial sheep farming in Fiji have failed, apparently (no formal studies were made) because of internal parasites, foot-rot, blow-fly strike, and uncontrolled dogs. There is now only one commercial flock.

There is a strong local demand for fresh mutton, which sells for up to 70c. a lb, considerably more than frozen New Zealand lamb, because people prefer fresh meat. In an experimental flock of Corriedales and Half-breds, bought from New Zealand and kept at Nawaicoba (near Nadi) since 1965, internal parasites have been controlled by fortnightly drenching in the wet season. This has been recommended to farmers, as has rotational grazing, also practised at Nawaicoba. Results there have been encouraging, with 75% annual weaned lamb production. The trial now described was devised to see to what extent this success has been due to (a) drenching and (b) rotational grazing.

EXPERIMENT

Method

At Nawaicoba, in December 1970, 138 lambs aged 3 to 5 months were weaned, drenched (with Thiabendazole) and on 12 January allocated to one of the following four treatment groups:

	Code	No. of sheep
Set grazed, not drenched*	S	19
Set grazed, drenched	SD	19
Rotationally g'z'd. not dr.*	R	50
Rot'ly g'z'd, drenched	RD	50

(*Not drenched initially; but some later treatment: see below)

The lambs were mainly cross-breds between Corriedale and N.Z. Half-breds, with some pure animals of each of these breeds. Each group had about equal numbers of females and castrated males.

Group S grazed one 9-acre paddock throughout, similarly SD. Group R used five separate paddocks totalling 25 ac. The number of grazing days spent in each varied according to paddock area, which ranged from 3.5 to 9 ac, but each paddock was always rested at least thirty days between grazings. Group RD grazed five other paddocks similarly. Thus the overall stocking rate of each group was 2 sheep/ac and each group was on separate land, free from cross-contaminations.

The pastures were predominantly Nadi blue grass *(Dicanthium caricosum)* with some Mission grass *(Pennisetum polystachyon)* and Siratro *(Phaseolus atropurpureus)*. They had all been previously grazed by similar animals so that their levels of contamination by free-living stages of helminths were about the same. All paddocks were provided with adequate shade and water.

Once a fortnight all animals were weighed and the SD are RD groups were drenched.

By April some of undrenched sheep appeared seriously worm-infested. On 6 April six sheep in group R were drenched, but three died soon after. These were replaced by other similar animals. Later, eleven sheep in group S were treated. By 25 May all the undrenched animals looked so bad that they were then treated, and this was repeated on 29 June. Thus, remembering that all the lambs had been drenched in December, the distinction between the S and R groups and the others was not that the former were completely 'undrenched' but that they were drenched only three (or in some cases four) times while the SD and RD groups were drenched twenty times.

Individual faecal samples were taken every four weeks and sent by air to Suva so that they arrived within six hours of having been taken. Eggs were counted by the 'Modified McMaster Technique' (7) and the helminth species present were determined by faecal cultures and larval differentiation (6).

Results : Liveweight

For each group the mean weight per sheep was about 36 lb on 12 January, and for a few weeks the growth rates of all the groups were about the same. Then, between the 4th and 8th week, the growth rates of the undrenched groups declined to zero, and for the next 10 weeks these groups lost weight until, by 15 May, they were down to about their starting weights. After the drenching of 25 May, however, they grew steadily, the S group faster than the R group, so that by 30 November the former had reached 57 lb and the latter 45 lb per sheep. (Table 1).

TABLE 1

MEAN LIVEWEIGHT PER SHEEP

		Not Drenched	Drenched	Mean
		lb	lb	lb
Set Grazing	15/ 5/71	36	54	45
	30/11/71	57	81	69
Rotational	15/ 5/71	36	47	41
Grazing	30/11/71	45	63	54
Mean	15/ 5/71	36	51	
	30/11/71	51	72	

Note : The S.Es of table entries due to within-group variation range from ± 1.0 to 2.0 at 15/5/71 and from ± 1.4 to 2.8 at 30/11/71.

Meanwhile, the SD group had grown steadily throughout to reach 81 lb by 30 November. The RD group, kept pace with the SD until June but then lost weight for four weeks and then grew at a lesser rate to reach only 57 lb by 30 November. These final weights were statistically analysed, but the 'within-group' errors thus obtained (Table 1) cannot validly be used to test significance between groups because of the lack of replication between pastures. They do show clearly, however, that the apparent main effects of drenching and of rotational versus set grazing are not due to between-sheep variation but must be due either to the treatments or to error variation between the particular fields used.

Results : Helminth studies

Groups SD and RD remained almost completely free of infection throughout (Table 2). Groups S and R suffered most from *Haemonchus* and *Cooperia spp* during February and March with substantial counts of *Bunostomum* and *Oesophagostomum spp* also in April and May. The deaths at this time were probably due to *Bunostomum* which is highly pathogenic. No eggs were found in these

TABLE 2

FAECAL EGG COUNTS AT EACH SAMPLING DATE

Mean eggs per gram of faeces.

Helminth genus	10/2	10/3	7/4	5/5	2/6	30/6	28/7	25/8	22/9	22/10	17/11
Rotationally grazed, drenched											
Haemonchus	—	—	—	—	—	16	—	—	—	—	—
Bunostomum	—	—	—	—	—	—	—	—	—	—	—
Cooperia	—	—	—	—	—	159	1	—	—	—	—
Oesophagostomum	—	—	—	—	—	—	—	—	—	—	—
Trichostrongylus	—	—	—	—	—	—	—	—	—	—	—
Rotationally grazed not drenched											
Haemonchus	189	53	78	234	—	206	34	3680	4705	4216	2518
Bunostomum	—	—	156	152	—	18	—	1619	136	651	—
Cooperia	371	1053	244	989	—	371	146	346	96	1599	—
Oesophagostomum	4	1	9	25	—	—	—	—	51	477	52
Trichostrongylus	—	—	—	—	—	431	8	—	85	2892	—
Set stocked drenched											
Haemonchus	—	—	—	—	—	11	—	—	—	—	—
Bunostomum	—	—	—	—	—	—	—	—	—	—	—
Cooperia	—	71	—	—	—	28	—	—	—	—	—
Oesophagostomum	—	—	—	—	—	—	—	—	—	—	—
Trichostrongylus	—	—	—	—	—	—	—	—	—	—	—
Set stocked not drenched											
Haemonchus	42	8	128	70	—	644	—	1127	2573	1288	1337
Bunostomum	—	—	560	31	—	—	—	18	—	—	—
Cooperia	147	332	720	685	—	1667	262	897	994	—	—
Oesophagostomum	3	39	192	100	—	35	—	35	—	—	7
Trichostrongylus	21	15	—	—	—	442	—	142	6192	2200	1925

groups after their May drenching, and few after that of July, but large numbers of these four genera, had returned to the R group by October and *Trichostrongylus spp* had appeared. This genus also appeared in the S group in large numbers, but in this group three of the original four genera were not present in October (Table 2).

No experimental animals were slaughtered for post mortem study of the correlation between egg counts and actual worm burdens.

DISCUSSION

It is evident that some degree of helminth control is essential for lamb rearing under these conditions; or, indeed, anywhere in Fiji as it is unlikely that the problem would be less severe elsewhere.

It is also evident that drenching, as practised in this trial, gives excellent control. Whether the two-week frequency is necessary is questionable. The fact that seriously high egg counts were found within five weeks of drenching (25 May to 30 June) in the S and R groups does not necessarily mean that a five-week interval is inadequately long as a regular practice, because under regular treatment pasture infestation might not build up to the levels it had on these R and S pastures by 25 May.

Rotational grazing, as practised in this trial, entirely failed to control infestation; indeed the helminth burden was greater in the R than the S group. Similar results have been obtained in a study of beef yearlings on a two-week grazing rotation (1) but in this study the rotational grazing gave greater body-weight gains and net profit per acre. Zimmerman (8) reported that two-week intervals of rotation of lambs through four pasture cycles was generally ineffective but one-week intervals on a six pasture cycle was moderately effective in controlling gastro-intestinal helminthosis. Durie (4) found that calves grazed on contaminated pasture that had been rested for 90 days still developed worm-infestation. Donald (3) found no significant decline in larval population on herbage for eight weeks after sheep removal.

In temperate countries there is a seasonal fluctuation in helminth incidence. The reduction in larval numbers due to rotation was found, in one study (5), to be small compared to seasonal difference. In a cattle study in Fiji, Donald (2) found a close relation between time of peak egg counts and age of calves, rather than season; but the possibility of a seasonal effect (probably due to variation in rainfall rather than temperature) in Fiji cannot be ruled out.

The loss in weight of the RD group in June may have been associated with the mild *Cooperia* infection they briefly acquired about then (see Table 2). It is otherwise difficult to explain this loss in weight, and subsequent lower growth rate than the SD group, because up to that time the two groups had been growing at the same rate. Possibly the one paddock used for the SD group was, for some reason, a little more productive through the dry season than the average of the paddocks used for RD. The single-field replication of SD permits no conclusion to be drawn on this point.

CONCLUSION

Helminth control is absolutely necessary for sheep rearing in Fiji. Drenching fortnightly gives excellent control, and possibly less frequently would be adequate. Rotation with a 4-week resting period is useless. Work elsewhere suggest that the resting period would have to be over 8-weeks to do any good.

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DALO (TARO) SPACING TRIALS, 1971

by

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SUMMARY

Field trials at Koronivia and Waidradra in 1971 confirmed earlier experimental suggestions that dalo spaced at (3 x 2) ft generally yields more than at (3 x 3) ft spacing. With ample soil nitrogen further substantial yield increases accompany closer spacing down to (2 x 2) ft, and (for two varieties) to (2 x 1½) ft. There is some evidence that if soil nitrogen is deficient there is little or no yield difference between (3 x 3) and (3 x 2) ft spacing and no evidence regarding closer spacing in this circumstance.

INTRODUCTION

Before 1972 there had been only three spacing experiments in Fiji with dalo *(Colocasia esculenta)*. These were planted at Koronivia Research Station with the variety Vavai Dina in the winters of 1965, 1966, and 1967, and harvested after about 11 months. They have been described in detail, and the results presented elsewhere (6). Table 1 now summarizes the results metrically.

TABLE 1: RESULTS OF 1965 - 1968 TRIALS

		Spacing approx. cm	N_0 1965/66	N_0 1966/67	N_0 1967/68	N_1 1967/68	N_2 1967/68
			Yield in Metric Tons Per Hectare				
FLAT	No Mulch	90 x 90	11.0	12.1	7.5	7.0	7.5
FLAT	No Mulch	90 x 75	12.5		7.8	8.0	9.0
FLAT	No Mulch	90 x 60	12.0	16.6	6.0	8.5	12.5
FLAT	Plastic Mulch	90 x 60	15.6	13.5	10.5	10.0	10.0
FLAT	Straw Mulch	90 x 90		16.1			
RIDGED (a)	No Mulch	90 x 90	9.9	8.5	See (6) for description of ridging treatments		
RIDGED (b)	No Mulch	90 x 90		9.8			
		S.E. ±	0.75	1.1	0.90	0.90	0.90

Only two spacing treatments were common to all three trials, i.e. (3 x 3) and (3 x 2) ft. In the 1965 and 1967 trials there was also a (3 x 2½) ft spacing. The first two trials were unfertilized. The third was a spacing (S) x nitrogen (N) factorial each spacing occurring with urea at the rates 0, 188, and 376 Kg/ha.

These treatments were all planted in what was described as the 'traditional' method, i.e. on the flat, unmulched. Various mulching and ridging treatments, as shown in Table 1, were also included, in one or more trials. The results of these cultural variations were discouraging and no further reference will be made to them here.

*On secondment from Rothamsted Experimental Station.

As noted by Hoskin (3 : see also 6) the S x N interaction in the 1967/8 trial was highly significant; so in considering the results over-all-trials only the N_0 results of this trial should be averaged with those of the other two giving :

Mean result in absence of N

3' x 3'	10.2 mt/ha
3' x 2'	11.5 mt/ha

The S.E. of these figures based on pooled "internal" errors of the trials is about ±0.5 mt/ha, so that this mean result was significant at only about 15% probability. The variation from trial to trial (i.e. the trial x spacing interaction) was rather more significant. The highly significant superiority of (3 x 2) over (3 x 3) ft spacing in the *presence* of N in the 1967/8 trial suggested that the trial-to-trial variation might be due to variation in N status of the soil.

The overall result therefore was a strong suggestion that (3 x 2) was better than (3 x 3) ft spacing, particularly in the presence of N, but the 1971 Departmental Field Manual recommends (3 x 3) ft spacing in conjunction with application of urea. Possibly the anonymous author of these recommendations gave more weight to what he believed to be traditional practice in Fiji and elsewhere, than to the results of these early experiments.

Fijian practice has never been thoroughly surveyed. Two brief notes (2,4) published about 1938 suggest respectively that traditional spacing is "4840 plants per acre" (ppa) and "3 ft apart on the triangle, i.e. about 5,000 ppa". Actually 3 ft square spacing gives 4,840 ppa : 3 ft triangular would give about 5,500. In the 1968 Census (1) 12,966 plots of 'pure' Dalo were enummerated but measurement of spacing (and yield) was confined to only 91 of these with the results now shown in Table 2. These suggest that spacings much wider than (3 x 3) ft are normal; but the corresponding yields strongly suggest that within these limits the closer the spacing the higher the yield.

Table 2 also shows the result of a survey in April 1972 by one of us (Prasad) of all dalo plots adjacent to the road between Koronivia and Waidradra, 20 miles away. In each of the 18 plots 20 plants were taken, effectively at random, and the distances between each such plant and its neighbours in each direction measured and averaged. In most of the plots the spacing varied little from plant to plant and averaged about 2.75 ft square. The variety appeared to be 'Samoa' in every plot.

The 1966-1968 experiments had one major fault, namely insufficient range of spacing. Yield is seldom much affected by variation in a 3:2 ratio in planting density. As a rule at the closer spacing the greater plant number is offset by lower yield per plant in approximate proportionality. It is the deviation from proportionality that causes difference in yield per unit area, and this deviation may be small. Thus it may be necessary for the dense spacing to have twice as many plants per hectare as the wide to detect a

TABLE 2

RESULTS OF SURVEYS

Survey	Province	Number of plots	Average number of plants/ac	Average Yield lb/plant	Average Yield lb/ac	Average Yield mt/ha	Average number of plants/ha
1968 CENSUS	Cakaudrove	23	800	2.4	2,000	2.2	1,900
	Tailevu	8	1,460	2.9	4,270	4.8	3,500
	Macuata	11	1,890	3.4	6,140	6.9	4,500
	Naitasiri	33	2,040	2.0	4,100	4.6	4,900
	Others	7	2,660	2.6	7,080	7.9	6,400
	Kadavu	9	3,600	2.0	7,100	8.0	8,650
1972 (Prasad)	Naitasiri	18	5,660	—	—	—	13,600

significant difference in yield per hectare. To cover the point of optimum spacing and demonstrate a significant drop in yield both at too close and at too wide spacing it may be necessary for the close spacing to have four times as many plants per hectare as the wide.

THE 1971 TRIALS

Description of trials

The first dalo spacing trial after that of 1967/68 was planted at Waidradra Research Station in February 1971, and another was planted at Koronivia on 4th March. Both were harvested in December, i.e. besides differing from the earlier trials in *location* (as regards Waidradra) and *planting* date, their *duration* was a little less.

Different *varieties* were also used: "Tausala-ni-Samoa" at Waidradra, and "Qawe-ni-Urau" and "Kurokece" in the Koronivia trial which was a spacing x variety factorial with spacing whole-plots split for variety. The Waidradra trial was a spacing x nitrogen factorial, with whole-plots split for three rates of urea: 0, 2, and 4 cwt/ac (0, 250, and 500 Kg/ha). In whole-plot layout the trials were identical with five spacings (see Table 3) ranging from (4 x 3) to (2 x 1½) ft in a 5 x 5 latin square.

The whole-plot size, excluding guard rows, was only 12ft square (1/302.5 ac, i.e. 1/122.5 ha), giving urea-treatment sub-plots at Waidradra of only 1/907 ac, unguarded, which is questionable.

At Koronivia urea was applied to all plots at 500 Kg/ha and at both sites superphosphate and potassum sulphate were applied at equal rates, 500 kg/ha at Koronivia and 280 kg/ha at Waidradra. Both trials were on Rewa soils, 'sandy loam' at Koronivia and 'sandy clay loam' at Waidradra. At both sites growth was good throughout with no appreciable occurance of pest or disease, and no severe drought or flooding.

Results

In the Waidradra trial urea depressed yield, significantly so at the higher rate;

	mt/ha	
N_0	15.9	±0.4
N_1	14.6	
N_2	13.6	

The interaction of spacing and fertilizer was negligible and non-significant, so the spacing result can be fully shown as in the first column of Table 3.

At Koronivia the varieties Qawe-ni-Urau and Kurokece yielded 14.0 and 17.5 (±0.8) mt/ha respectively, and there was an interaction with spacing the linear term of which was highly significant. The results of each variety therefore should be considered separately, as shown in Table 3.

Fig. 1 shows the mean results over both trials. The deviations from the linear trend of increasing yield with increasing number of plants are not statistically significant; but the freehand curve shown in Fig. 1 is a somewhat better fit than a straight line, and is in better accord with the general relationship of crop yield and spacing.

TABLE 3: RESULTS OF 1971 TRIALS

Ft	Cm	Plants/ac	Plants/ha	Waidradra (Mean of 3 N tmts)	Koronivia Kurokece	Koronivia Qawe ni Urau
				Yield in Metric Tons Per Hectare		
3 x 4	90 x 120	3,630	9,000	10.0	9.0	8.3
3 x 3	90 x 90	4,840	11,950	12.0	11.8	13.8
3 x 2	90 x 60	7,260	17,930	14.8	11.3	15.3
2 x 2	60 x 60	10,890	26,900	17.0	17.1	24.1
2 x 1½	60 x 45	14,520	35,860	20.0	20.3	26.1
				S.E. ±1.15	±1.7	±1.7

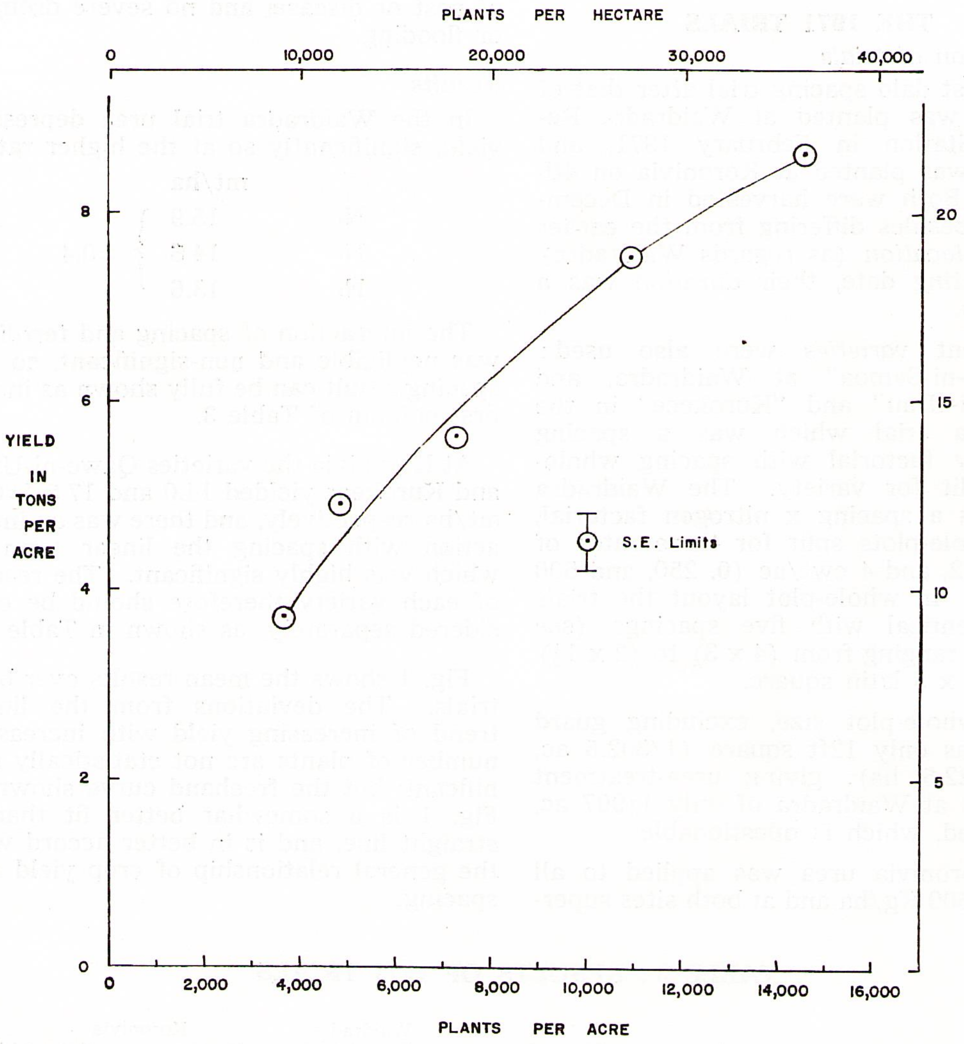

Figure 1. Mean yields of 1971 trials.

DISCUSSION

The extension of the range of treatments in these, as compared with the previous experiments, has clarified the situation greatly. In one of the two new trials N was applied to all plots, and in the other the lack of response to N suggests that there was no N deficiency in the unmanured plots, so the new results can be considered as being "in the presence of ample N" as were the N_2 plots of the 1967/8 trial. The new results not only confirm the big increase in yield of (3 x 2) over (3 x 3) ft spacing shown by those plots but also show that varieties Tausala-ni-Samoa, Kurokece and Qawe-ni-Urau continue, under the trial conditions, to give increasing yield with increasing plant population, certainly up to 11,000 ppa and probably, for the first two of these varieties, up to 14,000 ppa. The variety Vavai Dina has not been tried closer than 7,260 ppa, but its yield increase (with N) between 4,840 and 7,260 suggests that it will respond like the others, at least to moderately closer spacing.

The new trials provide no further information about the (S x N) interaction or the spacing effect when soil N is deficient. The apparent interaction in the 1967/8 trial, however, is so big as to arouse the suspicion that it is inflated by experimental error; so the confirmation of the superiority of (3 x 2) over (3 x 3) ft spacing in the presence of N casts doubt on the apparent opposite effect without N in that trial. It is probably true, as suggested also by the 1965/6 result, that when N is deficient there is little or no difference in yield between these two spacings; but unlikely that the wider ever yields appreciably more than the closer.

Studies eleswhere

C. esculenta is grown throughout the tropics as taro, cocoyams, eddo, etc.; but it seems that spacing has been little studied. In a recent thorough review (5) of this crop, from which the following notes are taken, only 8 out of 257 references were concerned with spacing.

Captain Cook reported upland taro in Hawaii at (4 x 4) ft and in West Africa cocoyams have been said to be planted at (3 x 3) ft. But much closer spacings (up to 43,560 ppa) are now used for irrigated taro in Hawaii and upland taro may be as close as 14,000 ppa. In two separate studies in India spacings of about 25-30,000 ppa outyielded wider spacings.

Thus it seems that in other countries, as in Fiji, there is a tendancy, confirmed by experiments, to use closer spacing than is traditional. The growing of irrigated taro in Hawaii closer than upland taro is analagous to our Fiji interaction of spacing and nitrogen in that in each case a soil deficiency (of water in the Hawaiian case) limits the use of very close spacing.

Value of produce

For many vegetable crops there is a point at which increasing yield with closer spacing is unprofitable because the decreasing size of fruits, tubers, etc. makes them less valuable per unit weight. Presumably at some point dalo corms would loose value because of small size. Within the size limits now found in markets, however, small and medium sized corms are favoured and large ones tend to fetch slightly lower price per lb.

The mean weight of the corms at (3 x 4) ft spacing, average of both 1971 trials was 2.4 lb (1.1 kg) and of those at the closest spacing was 1.6 lb (0.73 kg) the other treatments being intermediate. The latter are not too small to command as good a price per lb as any size.

Weed control

At the closer spacings, crop growth suppressed weeds better, particularly in the early stages. To some extent this was reflected in the yields, as the wider spaced plots were not kept so well weeded. But this was despite the fact that more labour was put into weeding the wider spaced plots, i.e. with increasingly close spacing there was an advantage from reduced weeding costs, besides increase in yield.

Planting costs

Suckers for research station plantings have been bought at 1c each, or more, at which rate close spacing is very expensive in planting material. For a new grower in an urban area this would be an important factor. An established grower, however, will usually have ample material from his previous crop, and in rural areas suckers are probably traded between farmers at much lower prices than Government can buy at. Some varieties sucker less prolifically than others, and suckering is generally less the closer the spacing, but at worst there should be an average of rather more than one sucker per plant, so that close spacing, as a general practice, will not be ruled out by lack of, or cost of, suckers.

The actual planting operation will require extra labour in proportion to the number of plants per acre. (One might guess that it is this factor that is largely responsible for the greatly sub-optimum spacing now practiced by many farmers). The saving in weed-control labour however will probably largely off-set this. An economic study is needed.

CONCLUSION

Under some circumstances very big increases in dalo yield can be secured by planting at spacings much closer than those previously recommended, and understood to be 'traditional'.

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ADDENDUM

Just before going to press a dalo spacing trial on the Fiji School of Agriculture section of Koronivia Research Station was harvested. There were seven spacings, ranging from (5 x 5) to (1.5 x 1.5) ft, ie 2,000-19,000 ppa and three varieties (Kurokece, Vavai Vula, and Vavai Loa) but only one small replicate of each variety, so that only the average yields of each spacing are meaningful. These were recorded as actual tuber weight, whereas all the yields given in this paper have been of dalo as marketed, ie tubers with about 40 cm of leaf-base attached, which weigh about 25% more than tubers alone.

The results of this School trial, scaled-up to allow for this difference in recording, are in remarkably close agreement with those shown in Fig 1. Three of the School trial spacings were within the range of the Fig 1 line, and their yields lay almost exactly on the line. Three were a little outside this range at the 'low' end, and these were almost exactly on a downward projection of the line. An exception was the yield of the closest spacings, which lay well above the upward projection, suggesting that yield continues to increase substantially with spacing even closer than the closest in our trials.

This suggestion is highly tentative, because the School trial had only enough replication to serve a teaching and demonstration purpose and not enough for any one treatment to give a conclusive result on its own. But for the treatment range (ie up to 14,000 ppa) where the School trial duplicated ours it affords valuable confirmation (and extension, to two more varieties) of our results. It now seems, therefore, reasonably certain that within this range for most varieties, the closer the spacing the higher the yield.

This addendum is based on notes by J. Berwick (lecturer) and F. Biutisuva (student) of the Fiji School of Agriculture, who will present their results in more detail in the next issue of this Journal.

AGRICULTURE, LAND USE, AND SMALLHOLDER FARMING PROBLEMS IN THE SIGATOKA VALLEY

by

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SUMMARY

A great range of arable crops is now grown by the smallholders who work the 45 km^2 of Sigatoka series soils on the floodplains of the Sigatoka valley. A tentative classification of suitability of the various soil types of this series for some of the main crops is described, and compared with present actual usage.

A detailed survey of 54 farms totalling 203 ha shows a dense population with a high proportion of children. Each year an increasing proportion of the farm produce must be used for home consumption leaving a very low cash income. Cropping is inefficient because the subsistence crops do not realize the full soil potential. The main barriers to development are over-population, insecurity of land tenure, slow adoption of new practices (irrigation, mechanization etc.) due to lack of capital and knowledge, and the low yield and unsuitability for summer cropping of most crop varieties now available.

INTRODUCTION

This report is a part of the material presented at the Twelfth Pacific Science Congress held in Canberra between August and September 1971. The Sigatoka Valley, as defined for this paper, consists of 363 sq km (140 sq miles) of alluvial and hilly land in south-west Viti Levu, Fiji and extends for 68 km (42 miles) from the Sigatoka River mouth in the south to Korovou Village in the north-east. A detailed soil survey of this area, at the scale of 1:25000, was done in 1970. Throughout the Sigatoka Valley there are narrow strips of floodplains which have two distinct levels of alluvial terrace. The upper terrace, standing at 11-13m above normal river level, is much the larger and more important agriculturally. The lower terrace occurs as isolated patches between the upper terrace and the river. Usually the surfaces of the terraces slope gently back from the river, the upper terrace being backed by foothills, mostly under 300m with a few rising to 600m. The main rock types are argillites and sandstones, siltstones, basic flows, limestone and marls (2, 3).

CLIMATE AND SOILS

The Sigatoka Valley has a lowland Fiji climate with a moderate dry season (4) which Fox (1) referred to as an intermediate zone. Mean annual rainfall over 28 years at the Sigatoka Research Station in the lower valley is 1900 mm and at Bemana in the upper valley the rainfall has averaged 2080 mm over 8 years. There is a distinct dry period in the cooler months from May to October which is the main season for market garden crops. Rice is only grown in the wet summer months between November and April. During four months of the year the rainfall is less than 103 mm per month, i.e. potential evapotranspiration exceeds precipitation; but there is little soil moisture deficit and in a normal year, except for shallow-rooted crops growing on sandy soils, plant growth is not retarded to any appreciable extent (5). At the Sigatoka Research Station the mean monthly temperature ranges between 26.5°C in January and 22°C in July, and there is most sunshine in December (6 hrs/day) and least in June (4.5 hrs/day).

The dominant soil on the floodplains occupying 45 km² is the alluvial Sigatoka Series, first defined by Fox (1) and adopted by Twyford and Wright (4), in which 16 soil types and 7 soil phases have been distinguished. The textural classifications of 21 of the 23 soil types and phases are shown in Fig. 1. The other two soil types (Sigatoka stony sandy loam and Sigatoka gravels) are of no great agronomic significance because of stoniness and/or yearly flood hazards and have been excluded from Fig. 1.

Other soils on the floodplains are Narewa and Matavelo series (gley soils) and Navosa peat (organic soil). Along the flat, coastal deltaic land the three main soils are Volivoli sand (developed from coastal sand-dunes), Dogo sandy clay (a saline soil of the marine marsh) and Korotogo sandy clay loam formed from beach material of a former shore platform.

LAND USE

Classification

Smallholder arable farming is the dominant system of agriculture practised on the Sigatoka Series. On these soils about 60 different varieties of vegetables, fruit, root and grain crops are grown by an estimated 1100 smallholder farmers. From the physical and chemical results of the detailed soil survey of the Sigatoka Valley and from observations of the distribution and yields of the various crops on the various soils, Fig. 1 has been constructed to indicate tentatively the optimum locations of the main crops. Most weight has been given to soil texture, hence water retention capacity.

Present Land Use

This tentative classification was compared with the present patterns of land use in a small area of Naduri mataqali land

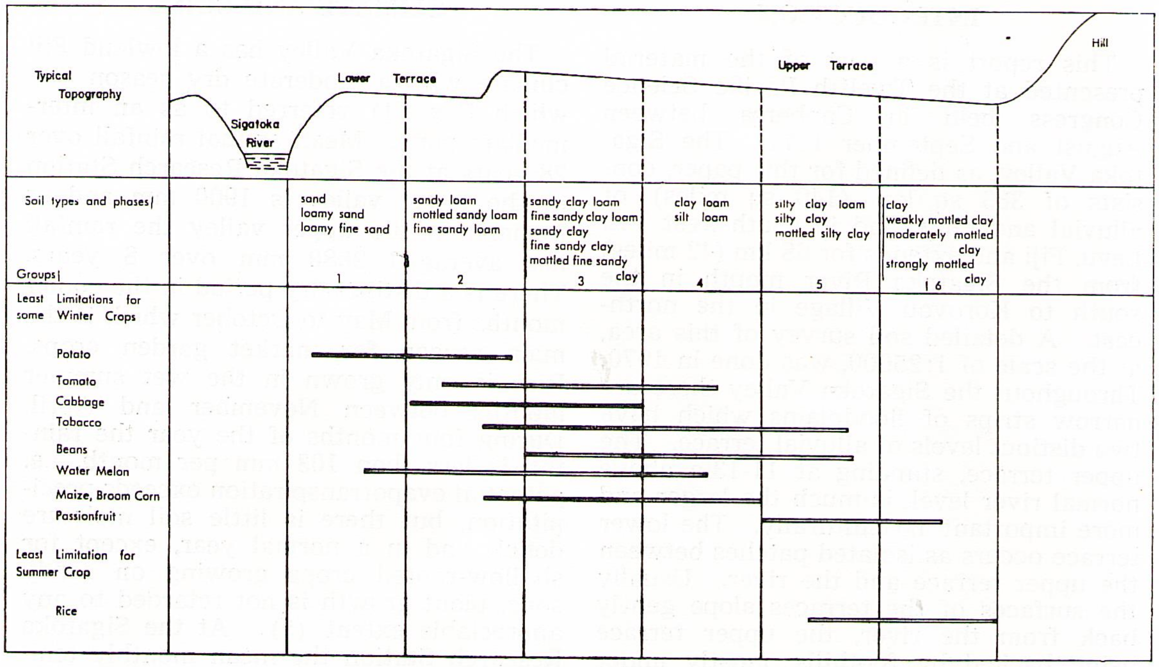

Figure 1. Land capability classification for Sigatoka Series soils.

on the right bank of the Sigatoka River in the lower valley (Fig. 2), comprising five arable land units whose particulars are listed in Table 1, and soil distribution shown in Fig. 3. The comparison showed a haphazard use of land. Instead of concentrating on one or two suitable crops it is usual to grow many crops on each farm, sometimes more than ten. One of the reasons for this is that 25-30% of the total farm production is consumed by the families operating the farms. Some crops such as rice, beans, tapioca (cassava), egg plants, cabbage, yams, kumala and bananas are used mainly on the farm. The main cash crops are maize, broom corn, tobacco, tomato, potato, water melon and passion fruit.

Weekly during 1970 and 1971 the yields of plots then being harvested on these farms was recorded. Rice grown on the best soils (group 6 in Fig. 1) averaged 1930 Kg/ha, compared with the national average of 1780 Kg/ha. Other average

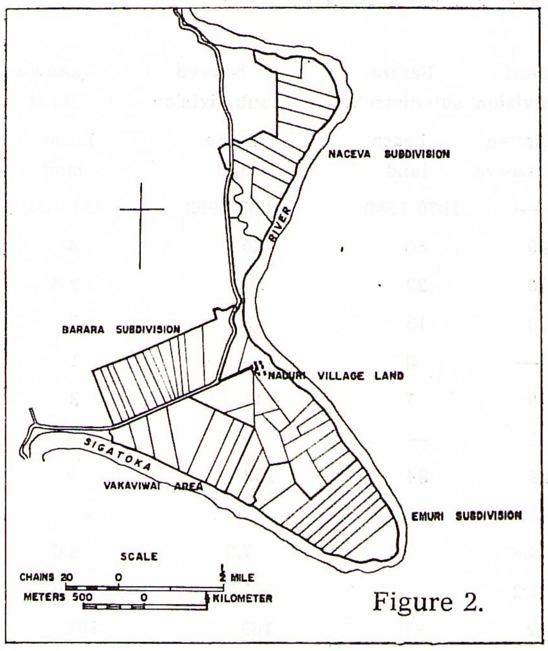

Figure 2.

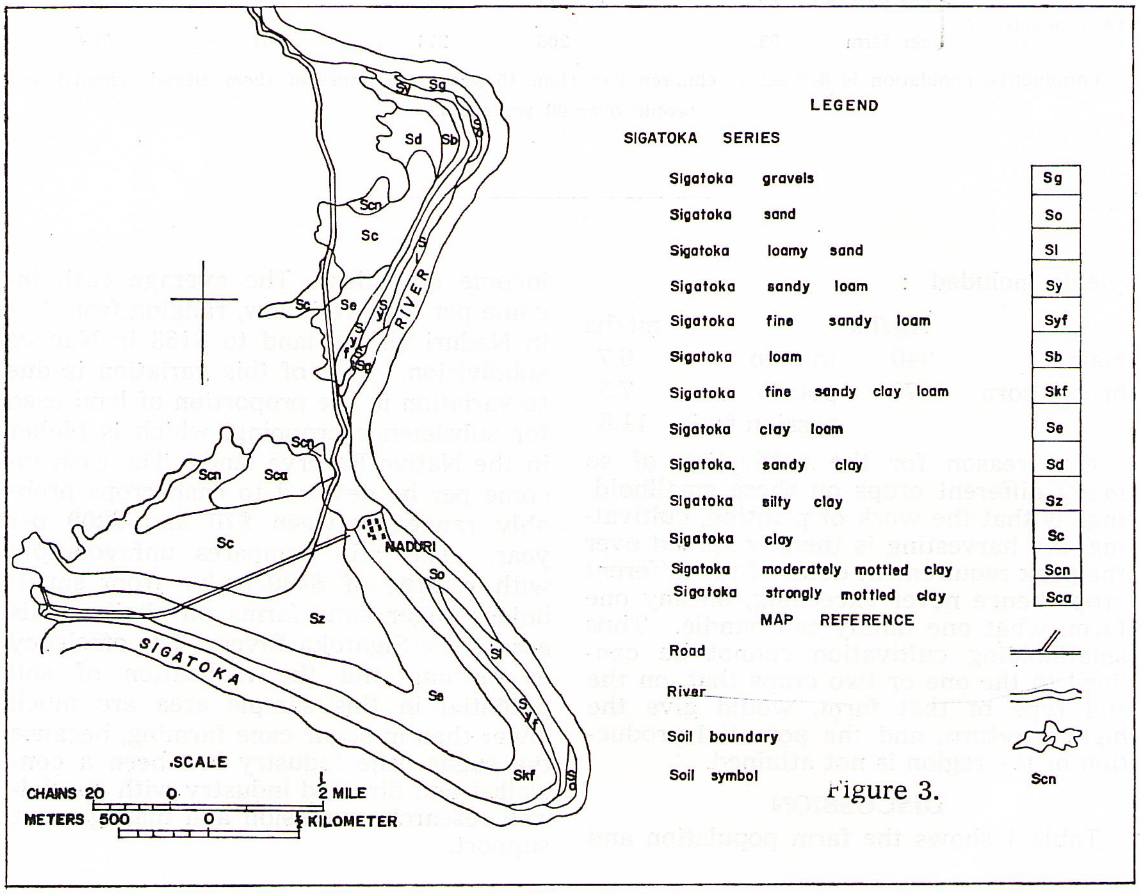

Figure 3.

TABLE 1 — STATISTICS OF AREAS SURVEYED

	Naduri village land	Emuri sub-division	Barara sub-division	Naceva sub-division	Vakaviwai Area
Land Tenure	Native Reserve	Native Reserve	Lease land	Lease land	Lease land
Lease Period	—	—	1970-1980	1963-1993	1915-2014
Area (ha)	26.7	40	40	60	36
Rent/ha, $	—	10	22	20	2.5
No. of Farms	11	10	13	13	7
Below 2.5 ha	10	—	6	—	1
Between 2.5 - 6 ha	—	9	7	11	3
Above 6 ha	1	1	—	2	3
Total Population (Pop'n)	54	48	84	103	56
% Pop'n unproductive*	41	42	35	52	45
Pop'n/Farm	4.9	4.8	6.5	7.9	8.0
Pop'n/ha	2.0	1.2	2.1	1.7	1.6
Average cash income, $ per ha	37	52	87	163	153
Average cash income, $ per person	19	43	42	96	98
Average cash income, $ per farm	93	206	271	761	797

*Unproductive population is defined as children less than 15 years old (most of them attend schools) and people over 60 years old.

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yields included :

	Kg/ha		mt/ha
maize	940	tomato	6.7
broom corn	1070	potato	7.5
		passion fruit	11.8

One reason for the cultivation of so many different crops on these smallholdings is that the work of planting, cultivating and harvesting is thereby spread over the peak requirement dates of the different crops hence never exceeding, on any one farm, what one family can handle. Thus smallholding cultivation cannot be confined to the one or two crops that, on the soil type of that farm, would give the highest return, and the potential production of the region is not attained.

DISCUSSION

Table 1 shows the farm population and income statistics. The average cash income per hectare is low, ranging from $37 in Naduri village land to $163 in Naceva subdivision. Part of this variation is due to variation in the proportion of land used for subsistence cropping, which is higher in the Native Reserve land. The cash income per ha devoted to cash crops probably ranges between $70 and $200 per year. This still compares unfavourably with returns of $480/ha/yr from smallholder sugar cane farms on similar soils across the Sigatoka River. The efficiency in farming and the realization of soil potential in this sample area are much lower than in sugar cane farming, because the sugar cane industry has been a controlled and directed industry with specialized research, extension and management support.

Although some farms have a shortage of labour during times of peak activity in the main cropping season, the major reasons for low productivity are poor farm management, inefficient farming techniques and low yielding varieties of the main cash crops. The problem of labour shortage could be overcome to some extent by greater use of farm machinery, but most of the smallholders do not have the necessary capital or the inclination to do this.

Land tenure and the different degrees of security is another problem that affects all production variables at the farm level. Between the three Native lease-land units there is a positive correlation between length of lease and farm output. Average annual cash income per farm in the Vakaviwai area is $797, in Naceva subdivision $761, and in Barara subdivision $271: the duration of lease to the expiry date in these areas is 43, 30 and 10 years respectively.

One change alone would increase the profitability of these farms enormously, and that is the introduction of varieties of tomato, lettuce, etc. with extended cropping seasons. There is an increasing demand from the urban areas and the tourist industry for high quality vegetables. Good prices are paid, but regularity of supply is essential. Most vegetable varieties now available give little or no yield when grown outside a short winter season.

Increasing crop yields and efficiency of farming will bring little or no increase in personal income if the present farming families remain tied to the land. Reference has already been made to the high proportion of land used for subsistence crops. The high 'unproductive population' figures of Table 1 relate mostly to children, indicating a rapidly rising population. Unless there is substantial migration, or increase in off-the-farm employment in this area, this rising population will demand an increase in land devoted to subsistence crops, and a decline in total cash income at the same time as the number of people sharing the income is increasing. This is the most serious immediate problem of this area. As said, although there is scope for increasing the volume and efficiency of production, that alone will not be enough.

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RICE RESEARCH IN FIJI 1960—1970
PART III WEED CONTROL

by

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SUMMARY

Before the introduction of short strawed rice varieties herbicide trials on dryland rice had shown no benefits or advantages over horse or tractor inter-row cultivation. From 1967 to 1971 herbicides were evaluated for use in short-stature, closer spaced dryland rice. Propanil applied post emergence at 3 lb a.i./ac. (3.4kg/ha), when weeds are at the 2-3 leaf stage and growing actively, was found to give good control of grasses as well as common dicots and was recommended for general use.

Trials in 1969 and 1970 with phenoxy herbicides (MCPA etc.) showed that these can be safely used to control broad leafed weeds at a later stage.

The weed problems of wetland rice depend on whether it is transplanted, or direct seeded. In the former case grass weeds are no problem and other weeds generally not serious, particularly under controlled irrigation (as opposed to rain-fed) conditions. Trials at Koronivia have shown that phenoxy herbicides applied 3-4 weeks after planting give adequate control in this case.

With direct seeding (broadcasting) on to puddled surface (as now practiced on the Rewa irrigated rice schemes), followed by flooding, grass weeds are a serious problem. Trials at Koronivia have shown that propanil is useful in this situation but not a complete success.

INTRODUCTION

The first formal study of weed control in rice in Fiji seems to have begun in 1957. By extending the nominal time range of this series of papers to include work from 1957 it is possible, therefore, to make this a comprehensive review of this subject to 1970.

All herbicides and weed species are mentioned in this paper by their common names except for the new or experimental herbicides having no designated common name. Chemical and trade names of most of them are listed in Appendix II of (9) and those of the reminder in Appendix I of this paper. Note that some herbicides were referred to in some earlier reports by their trade names, in particular propanil has been called 'STAM F-34' and trifluralin 'Treflan'. Botanical names of the weeds common in Fiji rice fields are given in Appendix II. Rates of application refer to the active material. Unhusked grains (paddy) yields of separate trials, given in earlier reports in lb/ac., are now summarized where possible by averaging over series of trials and presented in kg/ha with S.Es. either pooled or derived from treatments x trials interaction.

About half the rice in Fiji is grown as a dryland crop and until recently the reminder has been 'wetland' crop defined (17) as rice grown on rainfed puddled soil usually but not necessarily with water retaining bunds. A small but increasing acreage of wetland crop is now irrigated.

In annual reports of the period 1963 to 1969 the 'wetland' and 'irrigated' conditions were not always clearly differentiated.

DRYLAND TRIALS

All the trials now mentioned were 'main crop', i.e. were planted in November-December and harvested about May-June. Year dates refer to the second of the two years involved: i.e. a trial now said to have been made in 1968 may have been planted in December 1967.

Work with the older, tall, varieties

Formal experiments began in 1957. An account (21) of 'local practice' at about that time must be read with care to distinguish between the remarks referring to true local practice and those referring Koronivia Station practice. Moreover the former refer primarily to the practice that had been evolved on the ex-sugarcane land around Nausori where drilling at about 46cm (18in) is usual and inter-row cultivation common. Elsewhere, particularly in the dry zone where rice is taken as a subsistance catch crop in rotation with sugarcane, broadcasting is common.

Five trials in 1957-1960 on BG79 (75) and similar varieties involved 2, 4-D or MCPA in combination with several row spacings, with and without inter-row horse cultivation. It seems from the yields that the herbicides gave little or no control of weeds, and Rhodes' review of the results (12) consisted largely of an excellent account of cultural control, by implements (horse drawn inter-row cultivator, mechanical rotary hoe and tractor drawn steerage hoe) and by rotations.

These trials were followed at Koronivia, by project 'Rice 1/61' which involved four trials over three years (1960/61-1962/63). In these the three row spacing treatments listed below were combined with two seed rates of BG79 (75). The individual trial results are given in (13). Over all trials, the mean yield difference between the two seed rates was negligible and non-significant.

The row treatment mean yields were:

	kg/ha
Drilled 30cm hand weeded	2670
Drilled 46cm horse cultivated	2560
Drilled 60cm horse cultivated	2260
S.E.	±85

The extra yield of the hand weeded, closer spacing treatment was uneconomic.

Also in the 1963 annual report (13) was the first mention of the use of propanil in Fiji. In an observational trial it controlled sensitive plant but it was considered too costly for general use.

Two projects were begun in 1963. One, 'Rice 5/63', was a trial of four treatments repeated at Koronivia for three successive years with the results detailed in (18) and summarized now as:

	kg/ha
23cm rows + propanil 3.4 kg/ha	2110
34.5cm rows + propanil 3.4 kg/ha	2140
34.5cm rows + Hand Weeding	2560
46cm rows + horse cultivation	2460
S.E.	±141

The other project 'Rice 8/63' comprised two trials of three treatments in 1963/64 and three trials of six treatments in 1964/65, 66/67 and 67/68 seasons all at Dobuilevu. The detailed results have already been published (16). The 1967/68 trial was with IR8 and the results will be considered later. The other trials used tall, leafy varieties (Mutmuria, Saraya and Sonacalif) and the yields of the three treatments common in the four trials averaged:

	kg/ha
Broadcast + propanil 3.4 kg/ha	1760
Broadcast — No weeding	1150
Drilled 46cm rows and Inter-row cultivation	1850
S.E.	±281

while over the two trials involving six treatments the yields averaged as follows:

	kg/ha
Broadcast + propanil 3.4 kg/ha	1710
Broadcast — No weeding	690
Drilled 46cm rows and Inter-row cultivated	2090
Drilled 23cm + propanil 3.4 kg/ha	1960
Drilled 23cm + Hand weeding	1770
Drilled 23cm — No weeding	970
S.E.	±335

Thus, until the introduction of short-statured varieties it had been established that drilling the older varieties in 46cm rows, with inter-row cultivation gave reasonably good weed control and no advantage could be obtained by using propanil.

Spacing of the new varieties

But the results with IR8 in the 1967/68 trial of project 'Rice 8/63' were quite different, not only in that the general yield level was much higher than before, but also that drilling in rows at 46cm (18in) the yield was much less than drilling at 23cm (9in) or broadcasting. Weed infestation in this trial was negligible and all the five treatments i.e. drilled at 23cm (9in) and weeded by hand or by chemical or unweeded; broadcast with chemical weeding or no weeding, gave yields in the range of 6810-6925 (± 157) kg/ha while drilling at 46cm (18in) and inter-row horse cultivation gave only 5130 (± 157) kg/ha.

Later spacing trials (19,7,8) have confirmed that to obtain maximum yields with the dwarf, or semi-dwarf, varieties now being recommended planting at closer spacing is essential. Inter-row cultivation is therefore impossible, and the research emphasis is now on herbicides.

Evaluation of herbicides

For many years the phenoxy herbicides (MCPA, 2,4-D etc.) have been much used around the world for the control of dicots (dicotyledons) in rice. In 1960 Mune (4) recommended their use in Fiji and in recent years the dry-zone cane farmers, already familiar with the knapsacksprayer application of phenoxyherbicides to sugarcane, have used the same techniques on their catch-crops of dryland rice.

But although phenoxy herbicides can be a useful adjunct to inter-row cultivation, they are insufficient on their own as they give no control of the grasses which are generally the most serious weeds of non-inter-row cultivated dryland rice. In preliminary trials, during 1963-1967 (some of which were sown dry and later irrigated), propanil gave good control of grasses (1, 14, 15), and in two replicated trials on dryland rice in 1968 and 1969 the yields of a propanil treatment, and four other treatments common to both trials were :

	kg/ha
Propanil, 3.4 kg/ha, post-emergence	3020
MCPA 1.0 kg/ha, post-emergence	2040
Nitrofen 2.2 kg/ha pre-emergence	2050
Hand weeded, once	2570
Unweeded	1250
S.E.	±115

In the first of these trials glenbar was also included, but proved ineffective, and trifluralin, which gave good control of grasses but not of dicots. In the 1969 trail three triflurin rates were each combined with later application of 2,4,5,-T with good results. The 1969 trial also included several other rates and times of application of propanil (7).

These trial results with propanil appear excellent, but some drawbacks had appeared in farm usage. These, discussed in detail elsewhere (11), are related to sensitivity to weather and weed growth conditions at spraying time, lack of persistence, and the necessity of having better land preparation than many farmers could get with horse drawn implements. In the replicated trial the next year, (1970) a prolific second flush of weeds showed up the lack of persistence. The yields of the trial were also depressed by other factors, but extreme weediness was one reason why neither the propanil, nor any other treatment, gave a yield of IR8 of more than 1000 kg/ha. (8).

Meanwhile, in 1969 and 1970 further trials had been made with the phenoxy herbicides. The problem was that some common dicots (e.g. sensitive plant, cape gooseberry and kaumoce) were not effectively controlled by MCPA or 2,4,D at the normal rates, and the stronger 2,4,5-T was liable to damage the rice.

Three trials were made on farms in the Nausori area in 1969 one with early application (5-6 weeks after drilling) and two with later (8-9 weeks after) (7); and two trials on Koronivia Station in 1970, one with early and one with late application (8). It appeared that goat-weed, sensitive plant and kaumoce could be controlled by 2,4,D at suitable rates and times of application, while 2,4,5-T gave more certain control of these and had some effect on cape gooseberry. Both these could be used safely, 2-4 D up to 1.5 lb/ac. and 2,4,5-T up to 1.0 lb/oc., at the phase of maximum vegetative growth of the rice (about 5-6 weeks after sowing). On balance 2,4,5,T is most efficacious but, because of toxic impurities found in most commercial formulations its recommendation is dubious.

It seems that dicots can be controlled by post-emergence spraying; but the defects of propanil mentioned early still leave a need for a cheaper, more persistent,, and less weather/weed growth conditions dependent herbicide for grass control. Besides those mentioned above, OCS 21693, swep, alachlor, propachlor, and dichlobenil were tested in observational trials and show no promise.

Compatibility of propanil and insecticides

Interactions leading to phytotoxicity to rice, when organophosphorus and carbamate group insecticides and propanil are applied together or at short intervals have been reported (20). A trial at Koronivia in 1969 confirmed that application of propanil and insecticides in mixture is inadvisable, but usually a 4-day interval is safe. Of those studied only the carbamate insecticides, sevin and lannate needed a 9-day interval.

Recommendations (Dryland)

At the end of the period under review IR5 was the recommended variety. Drilling at 9in (23cm) or broadcasting following thorough cultivation was recommended. After the rice has emerged, and when weeds are in the 2-3 leaf stage and growing actively propanil should be applied at 3lb/ac. (3.4 kg/ha). At the current prices this will cost $5.25/ac. ($12.97/ha) for the chemical.

If 'local' tall varieties are planted, drilling at 18in (46cm) with subsequent interrow cultivation is recommended.

In either case if there is an appreciable infestation of broad leaved weeds about 5-6 weeks after sowing, the application of MCPA or 2,4-D at 1.0-1.5 lb/ac. (1.1-1.7 kg/ha) is recommended (2,4-D rather than MCPA if goat weed or sensitive plant are serious). At the current prices both MCPA and 2,4-D will cost about $1.20-1.80 /ac. ($2.96-4.44/ha).

WETLAND RICE

It is important to distinguish between the two methods of establishment i.e. transplanting and direct seeding and the two water supply situations i.e. rainfed and irrigated. It is best to distinguish primarily according to the method of sowing rather than water supply regime. This review is, however, complicated by the fact that just before the full introduction of double cropping under irrigation, several trials were drilled dry and then flooded. Trials conducted under this situation are summarized under the heading — Direct Seeding.

Transplanting

In highly mechanised irrigation scheme areas direct seeding is preferred but otherwise the wetland rice of Fiji is still transplanted. The great advantage of this situation is that the water cover itself is an effective weed control agent. Grass weeds are not a serious problem in transplanted wetland rice where preparation is adequate and water is controlled exactly (i.e. by irrigation, as opposed to reliance on rain). Sedges and dicot weeds (pickerel weed, bundaya, sesbania and false primrose) are the most common.

Before any formal trials were made small scale observation/demonstration trials showed the effectiveness of phenoxy herbicides (hormone weedkillers) like 2, 4-D, MCPA against dicots in rice and it was reported to be adopted by many farmers (3,5). Application of MCPA and 2,4-D at about 1.0 lb/ac. (1.1 kg/ha) about 3-4 weeks after transplanting gave good control of most weed and was recommended in 1960-61 (4, 12).

Experiments in 1966-67 (1) and 1968 (6) with molinate, trifluralin and nitrofen in transplanted, irrigated rice were inconclusive for the reasons just given. In the latest series of trials (see Table — 1) done on three consecutive crops at Koronivia starting with the 1969/70 main crop, the difference in yield between entirely weed free and unweeded plots averaged only 560 (± 187) kg/ha over three trials with a mean yield of 4400 kg/ha. These trials give a good estimate of the extent of the problem (i.e. the yield difference between 'weed-free' and 'unweeded' plots) but little else and leave little scope for detecting significant differences between treatments giving some intermediate degree of weed control. Results of these trials are reported in detail in the 1971 research report (10) not yet published and are also now shown in Table-1.

TABLE — 1

WEED CONTROL IN TRANSPLANTED IRRIGATED RICE

Season		69/70 Main	70 Second	70/71 Main	MEAN
Variety		IR8	IR5	IR5	—
Treatment	Rate † kg/ha	Yield -kg/ha		Paddy	
Molinate (g)-Pre-planting Incorporated	3.36	1850	6140	—	4030*
Nitrofen (g)-4-5 DAT	3.36	2080	6720	4300	4370
EPTC/MCPA (g)-4-5 DAT	1.68/0.67	2140	6290	4260	4230
Trifluralin/MCPA (g)-4-5 DAT	0.56/0.78	2270	6530	4220	4340
2,4-D IPE (g)-4-5 DAT	0.78	1980	6490	4340	4270
Machete (g)-4-5 DAT	3.36	—	4930	4030	3350*
Propanil (e.c.) when grass weeds at 2-3 leaf stage, applied after draining.	3.36	2040	6690	4700	4480
Molinate (e.c.) when weeds at 2-3 leaf stage, applied on water surface.	3.36	2320	6800	4420	4510
MCPA (a.c.) 3-4 weeks after transplanting.	1.12	2280	6760	4140	4390
Weed Free-Hand Weeded	—	2440	6760	4730	4640
Unweeded - Control	—	1500	6490‡	4260‡	4080
S.E.		±188	±212	±235	±123

NOTES :

g — granules.

e.c. — emulsion concentrate.

a.c. — aqueous concentrate.

DAT — Days after transplanting.

* — By missing plot technique.

† — Of active material.

‡ — Low infestation of weeds. Grass weeds negligible.

Although, as said, these trials were largely inconclusive, it has been observed that molinate was ineffective against sedges and pickerel weed and the chemical machete to be phytotoxic to the crop causing, despite an apparent quick recovery, a substantial loss of yield.

Direct Seeding

In the early stages of development of double cropping at Koronivia the land was prepared and drilled dry and then flooded. Trials in 1964 (14), 1965 (15) and 1967 (2) at Koronivia, and in 1968 on an adjacent farm (6), all showed that good immediate weed control was obtained by spraying with propanil at about 3.4 kg/ha after rice emergence when weeds were at the 2-3 leaf stage, and flooding then prevented reinfestation.

Trials are being continued with rice broadcast on a puddled surface, which is now the standard practice in Rewa irrigation scheme areas. Trials in the 1968 second season (6) and the 1968/69 main season (7) have again shown that good control of grasses and some of sedges and common dicots is given by propanil. It seems to be best when applied at 3.0 lb/ac. (3.4 kg/ha) to weeds at 2-3 leaf stage in the drained field which 2-3 days later is reflooded to prevent reinfestation. This is the current recommendation.

But the drawbacks of propanil mentioned in the 'dryland' section, particularly the sensitivity to weather conditions and weeds soon passing the optimum stage for spraying, still apply in this situation. In these trials the weather was fortunate; but in general use on Koronivia station prolonged wet weather has sometimes delayed spraying until the weeds were well beyond the optimum stage and then propanil is very much less effective.

Moreover, in these trials there was generally little weed, whereas severe infestations (particularly of barnyard grass and jungle rice) are now building up on some irrigated land in the Nausori area, and sometimes the dicots not controlled by propanil become serious pests. Thus this herbicides is not altogether satisfactory.

Of other herbicides studied in these trials, trifluralin (various rates and methods of application) was unsatisfactory. Molinate at 3.4 kg/ha incorporated in the soil pre-seeding gave excellent control of barnyard grass and jungle rice but was ineffective against sedges and pickerel weed. Nitrofen was inconsistent. OCS 21693 non-incorporated pre-seeding at 3.4 kg/ha severely damaged the rice. None of the herbicides applied pre-seeding was effective against sedges and the common dicots.

Since the period reviewed various other herbicides, mostly in granular form, that have given promising results in other countries (e.g. 2,4-D IPE, benthiocarb, machete, EPTC/MCPA) are being evaluated.

Chemical ploughing

On double cropped, irrigated land, drainage must be efficient otherwise such land, particularly boggy fields and those without a hard bottom pan, can present difficulties in preparation with heavy machinery. One possible solution is what has been called 'chemical ploughing' i.e. use of chemicals to 'burn off' or kill the stubble and weeds, and then transplant or broadcast seed without cultivation.

Paraquat, MSMA, DSMA, amitrole and cacodylic acid were tried for this purpose on fields under irrigation in the Nausori area during the main seasons of 1968/69 (7) and 1969/70 (8), followed by transplanting. The results, as detailed in (7) and (8) were promising but it is doubtful whether broadcasting would give an even stand on a surface covered with dead vegetation. A little light tillage (minimum cultivation practice) would help weed control, and might allow broadcasting.

Current Recommendations (Wetland)

In transplanted rice, sedges and dicots should be treated with MCPA or 2,4-D at 1.0 lb/ac. (1.1 kg/ha) three to four weeks after transplanting. Do not spray after the booting stage.

For direct sown rice under irrigation, propanil should be used as described earlier (drain field, spray weed in 2-3 leaf stage, reflood). If necessary, MCPA or 2,4-D can be used for the control of sedges and common dicots 5-6 weeks after sowing, as described for transplanted rice.

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APPENDIX I

List of common or trade names and their chemical equivalents of herbicides referred to in this paper and not mentioned in (Ref. 9) if any.

Common Name	Trade Name		
Amitrole	Weedazol — TL	—	3-amino-1,2,4,-triazole.
Benthiocarb	Saturn	—	-S-(4-chlorobenzyl)-N,N-dimethylthiol carbamate.
Cacodylic acid	Phytar (560)	—	dimethylarsinic acid.
2,4 — D IPE	Hedonal	—	2,4-D isopropyl ester.
Molinate	Ordram	—	S-ethyl NN-hexamethylenethiolocarbamate.
Propanil	Stam F — 34	—	3',4'-dichloropropionanilide.
2,4,5 — T	Nocweed 2,4,5 — T	—	2,4,5-trichlorophenoxyacetic acid.
—	OCS 21693	—	methyl 2,3,5,6-tetrachloro-N-methoxy-N-methylterephthalamate.

APPENDIX II

Common weeds found in rice in Fiji.

Wetland Rice

Scientific Name	Common Name
Ischaemum rugosum	— muraina grass
Echinochloa colonum	— jungle rice
Echinochloa crus-galli	— barnyard grass
Melochia corchorifolia	— bundaya
Jussiaea Spp.	— false primrose
Sesbania aculeata	— sesbania
Monochoria hastata	— pickerel weed
Cyperus pilosus	— sedge
Cyperus iria	— sedge
Cyperus miliaceae	— sedge
Cyperus polystachyos	— sedge
Fimbristylis dichotoma	— sedge

Dryland Rice

Ischaemum rugosum	— muraina grass
Echinochloa colonum	— jungle rice
Echinochloa crus-galli	— barnyard grass
Setaria pallidifusca	— cat's tail grass
Cuphea carthagenensis	— tar weed
Ageratum conyzoides	— goat weed
Mimosa pudica	— sensitive plant
Physalis angulata	— wild cape gooseberry
Cassia tora	— Kaumoce

THE ORIGIN OF THE AVIFAUNA OF URBAN & SUBURBAN SUVA, FIJI.

by

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SUMMARY

The birds to be seen regularly in Suva are listed. They are birds usually found in a wide range of habitats or normally restricted to mangrove forest, coastal forest or to dry zone vegetation. Rainforest species are not usually found in the city.

It is argued that the small number of species to be found in Suva is not a consequence of competition with introduced species but is to be expected in an oceanic island with a limited avifauna.

INTRODUCTION

The natural habitats of western Europe and many other temperate regions were destroyed long before bird study began and, as a result, it is now difficult to determine the natural habitat requirements of the birds living in these areas. In contrast, the birds of most tropical areas have not, until recently, been unduly influenced by man and his activities. Today, however, agriculture and urbanisation is proceeding apace in many parts of the tropics while the natural habitats, particularly rainforest, are being destroyed or grossly altered on an ever increasing scale. The time available for the study of tropical birds in their natural habitats is thus limited, the situation in Fiji being no exception. This paper considers those birds of Fiji which manage to live in the closest contact with man and his activities, in his towns and gardens, and the question of why they alone colonise the urban situation.

HABITATS OF VITI LEVU

The natural habitats of Viti Levu, together with those influenced by man's activities, have been described by Twyford & Wright (3).

The habitats considered in the present work are the following:

Salt-water swamp zone forest. Such forest provides insects, crustaceans, molluscs, fish and flowers as food for birds.

Dry zone vegetation. Food for insect and seed eating birds is abundant.

Lowland zone (wet) forest and mountain zone (wet) forest. Potential food for birds is abundant; nectar, fruit, seeds, and insects, but grass seed is rare.

I have classified together their Beach zone forest and forest developing from *teitei* under the heading Coastal Forest. Again food for birds is abundant; nectar, fruit, seeds, including grass seeds, and insects.

THE AVIFAUNA OF SUVA

Those indigenous and introduced birds which can be seen regularly in Suva and its suburbs are shown in Table 1. Those species to be seen in areas of light forest which have survived within Suva, for example on Battery Hill behind the University of the South Pacific, but which are not seen regularly in the city's gardens are not included. Such species include the Many-coloured Fruit Dove *Ptilinopus perousii* and the Slatyflycatcher *Mayrornis lessoni*. Table 1A also shows the natural habitats in which the indigenous birds living in Suva are to be found, based upon my observations in many parts of Viti Levu over the last eighteen months. Clearly it is not possible to speak meaningfully of the natural habitats of the birds introduced into Fiji, but Table 1B shows the Fijian habitats which have been invaded by these introduced species. With regard to rainforest I have included only those observations made on tracts of forest undisturbed by man. Although large areas of primary rainforest remain on Viti Levu, many areas, particularly near the coast, have been felled leading to the formation of secondary forest. Bird species more naturally associated with lowland coastal forest have invaded these areas of secondary growth. Such areas are not included in the present analysis.

TABLE 1

BIRDS LIVING IN SUVA AND THEIR NATURAL OR INVADED HABITATS ON VITI LEVU

	Salt-water -swamp Forest	Coastal Forest	Wet zone lowland Forest	Wet zone mountain Forest	Dry zone Vegetation
Section A *(Indigenous birds)*					
Fiji Goshawk. *Accipiter rufitorques.*	*	*	*	*	*
Swamp Harrier. *Circus approximans.*	*	*	*		*
Barn Owl. *Tyto alba.*	*	*			*
White-throated Pigeon. *Columba vitiensis.*		*			*
Collared Lory. *Phigys solitarius.*			*	*	
White-rumped Swiftlet. *Collocalia spodiopygia.*	*	*	*	*	*
White-collared Kingfisher. *Halcyon chloris.*	*	*			*
Woodswallow. *Artamus leucorhynchus.*	*	*			*
Polynesian Triller. *Lalage maculosa.*	*	*	*	*	*
Vanikoro Broadbill. *Myiagra vanikorensis.*	*	*	*	*	*
Orange-breasted Honeyeater. *Myzomela jugularis.*	*	*	*	*	*
Wattled Honeyeater. *Foulehaio carunculata.*	*	*	*	*	*
Grey-backed white-eye. *Zosterops lateralis.*		*			*
Parrot Finch *Erythrura cyanovirens.*		*	*		*
Section B Section B *(Introduced birds)*					
China Dove. *Streptopelia chinensis.*		*			*
Feral Pigeon. *Columba livia.*					
Bulbul. *Pycnonotus cafer.*	*	*	*	*	*
Indian Myna. *Acridotheres tristis.*	*	*	*		*
Jungle Myna. *Acridotheres fuscus.*	*	*	*		*
Strawberry Finch. *Amandava amandava.*		*			*
Rice Sparrow. *Padda oryzivora.*		*			*

DISCUSSION

Similar work on urban avifaunas in tropical Africa and Asia has shown that they are largely derived from species normally living in open grasslands or mangrove forest, rather than from species usually restricted to tropical rainforest. Thus Elgood and Sibley (1) have shown that the majority of garden birds in Ibadan, Nigeria are normally to be found on savanna, particularly in the light, open forest bordering streams, and Ward (4), working in urban Singapore, has shown that of the town's birds eleven are mangrove forest species, nineteen are from beach-ridge vegetation and only two are from the rainforest.

The situation in Fiji is essentially similar. The indigenous birds occurring in Suva (Table 1A) fall into two categories; a group of very adaptable birds found in all or most of the natural terrestrial habitats, and a group normally restricted to mangrove forest, coastal forest or to dry zone vegetation. Only one species normally restricted to the rainforest has invaded the city, the Collared Lory, a brush tongued species subsisting upon nectar, pollen and soft fruit, all of which are readily available in the suburban environment. None of the other species normally restricted to the rainforest, for example the Golden Dove *Ptilinopus luteovirens*, the Friendly Ground Dove *Gallicolumba stairii*, the Yellow-breasted Musk Parrot *Prosopeia personata*, the Fiji shrikebill *Clytorhynchus vitiensis*, the Blue-crested Broadbill *Myiagra azureocapilla*, the Fiji Warbler *Vitia ruficapilla* or the Giant Forest Honeyeater *Gymnomyza viridis* are to be seen regularly, if at all, in urban and suburban Suva.

The indigenous avifauna of the city consists, then, of several birds capable of surviving in all terrestrial habitats while the rest are normally to be found on dry grasslands, in mangrove forest or in lowland coastal forests. What is there in common between these three habitats and urban gardens which allows them to support similar avifaunas? Ward (4) suggested that mangrove forest and savanna are similar to man-made gardens in that they both have a relatively simple structure with a small number of plant species living at high densities, whereas tropical rainforest has a large number of species living at low densities. Thus, in a sense, birds living in mangrove forest and savanna are pre-adapted for life in urban gardens. In Fiji, mangrove forest, coastal forest and dry zone vegetation do indeed present a much more simple and open habitat than does the tropical rainforest, and in this sense they closely resemble the man made situation. The openess and simplicity of structure appear to be the dominant characteristics in common between the suburban environment, mangrove forest, coastal forest and dry zone vegetation.

Suva has, living within its confines, seven species of birds which have been introduced into Fiji in recent times (Table 1B). Three of these species, the Jungle Myna, the Indian Myna and the Red-vented Bulbul are adaptable and aggressive birds which have invaded most of the terrestrial habitats of Viti Levu. These three species are particularly common in Suva and it is often claimed that they must have forced the native birds out of the city deep into the rainforest, thus accounting for the paucity of the city's avifauna. Without information on the status of Suva's birds before the introduction of the Mynas and Bulbul it is difficult to evaluate their impact. Moreover, while the introduced species have multiplied there has been a great increase in human population, in land clearance and building, in industry and in vehicular traffic. It would be difficult to separate the effects upon the city's indigenous birds of competition from introduced species and man's increasing activity.

I suggest that in view of Fiji's relatively small terrestrial avifauna of only 59 species, one would not expect to find a greater number of bird species living within the city. As it is, fourteen, or 24% of the total number of species to be found in the whole group, are to be seen regularly within Suva. Compare Singapore, on the edge of the Malaysian Peninsula with its 550 species of land birds, which has only thirty two species regularly visiting its gardens (4), or mainland Malayan gardens with only about forty bird species (2).

The inability of rainforest species to adapt to urban and suburban situations would appear to be a general phenomenon; Suva's paucity of bird life is to be expected, situated as it is on an oceanic island with a limited avifauna and whose major natural habitat is tropical rainforest.

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THE EFFECTS OF DIET AND STOCKING RATE ON BROILER CHICKEN GROWTH

by

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SUMMARY

In a trial at Koronivia, chickens kept penned at 0.95, 1.05, and 1.36 sq ft per bird averaged about 4.25 lb liveweight at 9 weeks old with only a 0.16 lb difference between the highest and lowest stocking rates. The net returns per pen (value of produce less cost of day-old-chicks, feed, and medicines) were $401, 374, and 294 per pen respectively for the high, medium, and low stocking rates. There was no appreciable difference between the two feeds compard.

INTRODUCTION

There is some evidence from temperate climates that the optimum stocking rate of chickens reared on deep litter is about 0.6 sq ft per bird (1, 3) or perhaps up to 1.0 sq ft (2). The optimum stocking rates for rearing broiler chickens in the tropics could be lower than these because of higher temperatures and relative humidities. In an experiment at Koronivia Research Station in 1971 the growth rates of broilers were compared, using two locally produced rations not previously examined experimentally and three different stocking rates.

EXPERIMENT

Method

Six contiguous pens of about 450 sq ft each were destocked about six months before the experiment and disinfected. Two pens were then stocked with day-old chicks at a rate of 500 per pen, two at 450 and two at 375 (i.e. 0.9, 1.0, and 1.2 sq ft per bird respectively). Before arrival the birds were treated with pidgeon-pox vaccine and sexed, each pen being given about equal numbers of males and females.

The sides of the pens were netted to provide adequate air circulation, the floors were covered with wood shavings, and heaters were used at night for the first two weeks. Water was supplied *ad lib* throughout as was feed, through self feeders, one of the two pen at each stocking rate being on feed A and the other on B (see Appendix). The trial was therefore, in effect, a 3 Rates x 2 Feeds factorial with one pen of each treatment.

The birds which died during the first two days were replaced, but not thereafter. All the chickens were weighed at one week old, samples were then weighed at weekly intervals, and at 9 weeks all the birds were weighed slaughtered, and reweighed after dressing.

Results

Table 1 shows the final actual stocking rates of each pen, and the final mean live and dressed weights, and costs of food etc. The exceptional death rate of one pen was due to 62 birds dying during the last five days of the first week, seemingly because the birds became frightened and rushed to one corner of the pen where some were smothered.

DISCUSSION

Because of the lack of pen replication no statistical significance can be attached to the apparent differences seen in Table 1, but the practical significances are clear.

Between feeds there is a slight difference in mean liveweight per bird (4.34 lb on feed B, 4.17 on A) and a proportional difference between dressed weights; but the birds on B ate slightly more so that feed conversion (lb feed eaten per lb liveweight gained) figures were almost identical (2.26 for feed A, and 2.24 for B, from the first to last weighings). This is much better than the minimum of 3.62 lb feed per lb liveweight gain reported by Marais (3).

TABLE 1. **RESULTS**

		FEED A			FEED B	
Stocking rate (sq ft per bird)	0.9	1.0	1.2	0.9	1.0	1.2
Death rate	5.2%	5.2%	5.2%	5.6%	6.9%	11.8%
Actual final stocking rate — sq ft per bird	0.95	1.06	1.26	0.95	1.07	1.47
Actual final stocking rate — no. of birds	474	425	356	472	419	306
Liveweight at 9 weeks. lb/bird	4.06	4.23	4.22	4.28	4.32	4.44
Dressed weight at 9 weeks. lb/bird	3.24	3.42	3.40	3.38	3.32	3.70
Gross return per pen	$712	$680	$548	$747	$666	$521
Cost of chickens $	100	90	74	100	90	74
Cost of feed $	211	199	163	236	210	163
Cost of medicine* $	5	4	3	5	4	3
Total cost $	316	293	240	341	304	240
Net return per pen $	396	387	308	406	362	281
Net return per bird cents	85	93	91	87	86	94

* A total of 1.2 Kg 'Toltro', for coccidiosis control, and 450 ml of 'Floxaid', an antibiotic for general stress.

Feed A at 5 cents/lb was a little cheaper than B at 5.5 cents, because a small part of its protein was made up of cheap local coconut meal (see Appendix), hence was the more profitable with a mean net return of $364 per pen compared with $349 for feed B.

As regards stocking rate, the decrease in bird weight with increased stocking, although small and of dubious statistical significance, makes sense and can be taken as genuine. The differences between profitabilities per pen are enormous and must be considered as highly significant:

Stocking rate	Liveweight per bird	Net return per pen
sq ft per bird	lb	$
0.9	4.17	401
1.0	4.27	374
1.2	4.33	294

These figures are extremely promising. It is possible that still heavier stocking rates may give still better gross return, and that the cost of feed could be further lowered, with no loss in value, by increasing the proportion of locally produced components. But this trial ran during the winter months of June, July, and August, and the mean maximum and mean minimum temperatures of the trial period were only about 80 and 68°F respectively. It is possible that these high stocking rates will not be so successful in the summer when the mean monthly maximum and minimum temperatures reach 86 and 74°F respectively.

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APPENDIX

Percentage Compositions of the Feeds

	Feed A		Feed B	
	Starter	Finisher	Starter	Finisher
Constituents				
Wheat	63	68	64	70
Fishmeal	16	13	11	10
Soybean meal	—	—	13	10
Meat meal	12	7	4	4
Skimmilk powder	—	—	2	—
Molasses	3	3	3	3
Broiler pre-mix*	3	3	3	3
Coconut meal	3	6	—	—
Salt	trace	trace		
	100	100	100	100
Analysis				
Moisture	11.4	11.2	11.7	11.3
Crude protein	23.9	20.7	23.9	21.9
Fat	5.1	3.9	3.4	3.6
Fibre	2.4	2.5	2.4	2.0
Calcium	2.8	2.8	1.6	1.7
Phosphorus	1.3	1.5	1.0	1.1

*A mineral — vitamin mixture.
Starter: used for first 3 weeks.
Finisher: used for next 6 weeks.

RESEARCH ABSTRACTS

Unless otherwise stated the authors are staff of the Research Division of the Department of Agriculture Fiji.

FIRMAN, I. D.* Black leaf streak of bananas in Fiji. *Ann. appl. Biol.* (1972) **70**, 19-24.

Black leaf streak of bananas, caused by *Mycosphaerella sp.*, prevented fruit of export quality forming and bunches maturing. Some infected leaves lived less than 50 days and were seldom retained until harvest. Maneb or benomyl applied in oil/water emulsions gave good control and benomyl was so effective that plants had ten leaves at harvest and some leaves survived for 245 days. Plants sprayed with maneb or benomyl flowered 1 month early. No benomyl residues were detected in the fruit exported to New Zealand. The control of black leaf streak by sprays containing oil has caused other leaf diseases to become more prevalent and the ensuing complex disease situation is discussed.

* Now of School of Biological Sciences, University of Bath, England.

VERNON, A. J. and SUNDERAM, S. Current cocoa research in Fiji (Paper presented, by P. Sivan, at the 4th Internat. Cocoa Conf., Trinidad, Jan 1972 : will be published in Conf. Proc.)

Only Amelonado cocoa is now being planted in Fiji. Experiments superimposed on standing cocoa comprise a chupon pruning trial, in which completely unpruned cocoa is yielding remarkably well, a shade and manurial trial in which the unshaded plots are yielding at the rate of 3,000 kg/ha and showing no response to any fertilizer, a time of fertilizer application trial with an unusual design, and a trial of the effect of fertilizer in the third and fourth years after planting. Especially planted trials comprise a Spacing x Pruning x Establishment Method factorial in which directly sown socoa has established much better than transplants, two spacing trials (one under coconuts) a trial comparing four species of shade trees, and a series of trials comparing Amelonado with seven hybrids of Amelonado and various I.C.S. and Sca. clones.

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