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Nutritional status of cocoa in Papua New Guinea

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Paul N. Nelson, Michael J. Webb, Suzanne Berthelsen, George Curry, David Yinil and Chris Fidelis

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Cover: Sampling and sieving soil at survey site 2 for analysis of soil characteristics (Photo: Mike Webb)

Foreword

Demand for chocolate, 'the food of the gods', is rising inexorably, creating opportunity for countries like Papua New Guinea (PNG), which has ideal growing conditions for cocoa in the coastal lowlands. PNG produces less than 2% of the world's cocoa, but the crop is extremely important for many people's livelihoods. An estimated 151,000 households rely on cocoa as one of their principal sources of income. Cocoa from PNG is known for its good and consistent quality, with particular flavour, high fat content and large beans.

Cocoa was introduced to PNG in 1880 by German traders, and the industry developed slowly until the 1950s when the Australian administration promoted its cultivation among villagers. It is now one of the four major export tree crops cultivated in the 14 coastal provinces of PNG. Cocoa plantings occupy approximately 27% of the total area of 476,000 ha under export tree crops. Approximately 80% of the crop is produced by smallholders and this proportion is likely to increase.

Despite the healthy market demand for cocoa, smallholder yields in PNG have generally been far lower than those potentially attainable, and recently they have fallen even further due to widening infestations of cocoa pod borer. For the cocoa industry to recover and prosper, it is essential that management of smallholder cocoa blocks improves dramatically. Many aspects of good management, such as pest control, are fairly well understood, and the Australian Centre for International Agricultural Research (ACIAR) has been involved in partnerships with PNG organisations to carry out some of the necessary research. However, there is little information on appropriate nutrient management for cocoa in PNG. Therefore, ACIAR supported this study to identify possible nutrition-related constraints on productivity and recommend what steps should be taken next. I hope that the results of this detailed, nationwide study will lead to increased productivity of this important tree crop.

Nick Austin
Chief Executive Officer
ACIAR

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Abbreviations

Al	aluminium
B	boron
C	carbon
Ca	calcium
$CaCl_2$	calcium chloride
CCI	Cocoa Coconut Institute, Papua New Guinea
CEC	cation exchange capacity
Co	cobalt
$cmol_c$	centimoles of charge
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
Cu	copper
DTPA	diethylene triamine penta-acetic acid
EC	electrical conductivity
Fe	iron
ha	hectare
IPDM	integrated pest and disease management
K	potassium
KCl	potassium chloride
kg	kilogram
M	molar
Mg	magnesium
mg	milligram
Mn	manganese
N	nitrogen
$NaHCO_3$	sodium bicarbonate
NARI	National Agricultural Research Institute, Papua New Guinea
Ni	nickel
P	phosphorus
PBI	phosphate buffer index
PGK	Papua New Guinea kina
PNG	Papua New Guinea
PNGRIS	Papua New Guinea Resource Information System
PSI	phosphate sorption index
S	sulfur
t	tonne
Ti	titanium
VSD	vascular streak disease
XRD	X-ray diffraction
XRF	X-ray fluorescence
Zn	zinc

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The PNG Oil Palm Research Association, particularly Dr Murom Banabas, provided assistance during the survey in Northern Province.

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The PNG Cocoa Board contributed PGK30,000 towards holding the second workshop.

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Professor George Curry has extensive fieldwork experience in rural villages in PNG. His recent work in cash crop production employs a sustainable livelihoods approach to investigate the socioagronomic constraints on smallholder oil palm and cocoa production. He is particularly interested in how the cultural values and organisation of labour associated with the subsistence economy have been carried over into cash cropping to influence smallholder productivity.

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Summary

Cocoa is grown by approximately 151,000 households in Papua New Guinea (PNG). Smallholders, who produce 80% of the crop, have annual yields far below the potential of 4.4 tonnes/hectare. Yields are low for many socioeconomic and agronomic reasons. The aim of this study was to determine the nutrient status of cocoa grown in PNG, and to recommend further steps to determine if there are nutrient-related constraints on productivity and how they might be overcome.

Leaf and soil nutrient contents were measured and grower practices were recorded at 63 cocoa blocks (smallholders, on plantations or on research stations) across the country. A wide variety of plant species were present in blocks, with *Gliricidia* being the most common shade tree. Based on published 'critical' levels for cocoa leaf nutrient contents, nitrogen and iron deficiencies occurred in more than 89% of the blocks and phosphorus deficiencies in about 25%. Leaf magnesium concentrations were mostly adequate, except in East New Britain, where 64% of the blocks were deficient. Deficiencies of potassium, calcium, manganese, boron, copper and zinc were encountered in 2–15% of the blocks. However, the 'critical' levels must be regarded with caution, as the micronutrient (manganese, boron, copper, iron and zinc) values were based on surveys rather than manipulative experiments, and the macronutrient (nitrogen, phosphorus, potassium, magnesium and calcium) values were established in different places with different planting materials. Leaf potassium and phosphorus contents were related to soil type and nutrient contents. In blocks that are being well maintained and regularly harvested, it is likely that yield is being constrained by nutrient deficiencies.

Management of cocoa blocks in PNG must improve dramatically for the cocoa industry to prosper, and perhaps even to survive, particularly with the recent spread of cocoa pod borer, which is drastically reducing cocoa yields. To improve management and yields, the industry requires reliable critical levels of leaf nutrient concentrations, and nutrient management recommendations appropriate to different regions, based on trials. Effective means of facilitating adoption of improved practices must also be developed.

Background and aims

Cocoa (*Theobroma cacao*) is one of the most economically important cash crops in PNG. It is the primary cash crop in most coastal areas of PNG, being grown on an estimated 100,000–130,000 hectares (ha) by around 151,000 smallholders or 16% of the households in the country. Just over one million people in PNG depend on cocoa for their livelihood (Omuru et al. 2001).

In 2009, exported cocoa was estimated at 51,000 tonnes (t), bringing in annual export earnings of around PGK331 million. However, the industry is threatened by cocoa pod borer (*Conopomorpha cramerella*). Until 2008, the Gazelle Peninsula of East New Britain province was the most important cocoa-growing region, producing about 20,000 t or 54% of national production. In 2009, annual production from East New Britain fell by over 60% to approximately 8,000 t (C.S. Parik, economist, Cocoa Board, pers. comm.) because of losses to cocoa pod borer. This loss in production was offset by increased production from the Autonomous Region of Bougainville and East Sepik province. Cocoa pod borer is present in both these provinces and in Madang province, and poses the most serious challenge to the industry in the coming years.

Plantation production of cocoa has been declining since the mid 1970s mainly because of rising production costs and the closure of the Bougainville plantations in 1988–89 with the outbreak of civil war in that province. In contrast, smallholder production has been on the rise from about 6,800 t in 1972–73 to its present level of approximately 40,000 t.

Despite the importance of cocoa to the economy, the industry is plagued by poor management practices that result in low yields. Most PNG smallholder cocoa is currently produced using a 'foraging' production strategy with virtually no management inputs. Yields are very low, generally in the range 0.3–0.4 t/ha of dry bean annually. Yield potential is much higher, with yields of up to 4.4 t/ha observed in research trials, and between 1.5 t/ha and 2.5 t/ha obtained in plantations.

Given the size of the smallholder contribution to the industry, it is clear that even a small increase in smallholder productivity could have a substantial effect on export income and increase growers' cash income. For the industry to survive and prosper, management inputs to smallholder cocoa blocks must improve substantially. This is particularly important with the recent spread of cocoa pod borer, because the pest can devastate crops unless levels of management are high. Good nutrient management is an important part of the picture; however, there is little information on nutrient management to guide PNG cocoa growers. Even if nutrient management were improved, no lift in productivity would be expected without improved management of cocoa and shade trees, pests and diseases, weeds and harvesting.

The purpose of this study was to determine the nutrient status of cocoa trees and cocoa-growing soils throughout the key growing areas of the country. The information is intended to help assess whether or not productivity is constrained by nutrition and related factors, to help design future research activities that address possible constraints, to provide recommendations to overcome possible nutrition-related constraints on productivity and to implement solutions.