

**BIOLOGICAL NITROGEN FIXATION BY  
COVER LEGUMES UNDER OIL PALM  
PLANTATIONS IN PAPUA NEW GUINEA**

**A thesis submitted in fulfilment of the requirements  
for the degree of**

**Master of Agricultural Science**

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**Faculty of Sciences**

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Dedicated to the memory of my father Mr Nehemiah Pipai Ndramat



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## Abstract

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Sustainable management of soil nutrients, and more generally soil health, is a priority concern for the Papua New Guinea oil palm industry, as it is for most other agricultural systems in the world. Like other crops, oil palms need essential elements such as N, P, K and Mg in large amounts annually in order to maintain high fresh fruit bunches (FFB) production. Nutrients are supplied in the form of mineral fertilizers annually to meet nutritional requirements. Legume cover plants used under the oil palm for weed suppression and erosion control also contribute N to the oil palm system through biological N fixation, although amounts of N fixed have not been quantified for these legumes in PNG oil palm plantations. In this study, the xylem ureide technique was calibrated in a glasshouse experiment using  $^{15}\text{N}$  isotope dilution for the legume cover species *Calopogonium mucunoides*, *Pueraria phaseoloides* and *Mucuna pruriens*, before being applied in PNG oil palm plantations to assess  $\text{N}_2$  fixation by these cover legume species and *Calopogonium caeruleum*. Legume standing shoot biomass under 2 to 25 year old plantations was 144 to 443  $\text{g/m}^2$  and litter was 100 to 804  $\text{g/m}^2$ , equating to an estimated mean 400 kg/ha shoot biomass per plantation. Legume shoot N was 3.5 to 12  $\text{g/m}^2$  while the litter N was 1.8 to 22  $\text{g/m}^2$  with a mean plantation shoot N estimate of 10 kg/ha. Dependence on  $\text{N}_2$  fixation was highly variable, ranging from 18 (*P. phaseoloides*) to 75% (*C. mucunoides*), and did not show any relationship with age of plantation but was significantly lower where soil nitrate-N was high. Amounts of N fixed were 1.5 to 4.4  $\text{g/m}^2$  for standing shoot and 0.9 to 6.0  $\text{g/m}^2$  for litter equating to plantation estimates from 0.3 (*C. mucunoides*) to 34 (*P. phaseoloides*) kg N fixed/ha. These were conservative estimates since the study did not account for N in roots and furthermore only measured standing biomass rather than annual production. Estimates were based on measures of actual percent legume cover (0.6 to 44%) - hence indicated potential for increasing inputs of fixed N by managing for greater cover. Further research is recommended to quantify legume biomass production over time, including litter and root accumulation and turnover. Nevertheless, except for *M. pruriens* which did not transport a large proportion of fixed N as ureides, this study successfully calibrated the ureide technique to quantify input of biologically fixed N from cover legumes in the PNG oil palm system. With this knowledge, more informed decisions can be made regarding the effective management of N inputs from fertilisers and legumes in order to achieve sustainable oil palm cultivation.



## **Thesis declaration**

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I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Rachel Pipai



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