AN ASSESSMENT OF THE NITROGEN FERTILIZER REQUIREMENTS OF WINTER CABBAGES (*Brassica oleracea* var. *capitata* L.)

A thesis presented in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy in Soil Science
at Massey University

ROBERTO REGINALDO BONOAN

1990

ABSTRACT

The increasing costs of N fertilizers and the danger of creating environmental pollution due to excessive N fertilisation practices create a need for more efficient N fertilisation of vegetable crops. This present study was conducted with the main objective of assessing the N fertilizer requirements of winter cabbages on a coarse loamy mixed mesic Dystric Eutrochrept soil and consequently developing a model which would assist in predicting N fertilizer requirements over a wider area.

Glasshouse and field experiments were conducted to assess the utility of soil and plant (sap) tests for assisting in determining the N fertilizer requirements of winter cabbages. The concentrations of NO_3-N and NH_4-N in either the xylem or petiole sap of cabbages were found to be influenced by several factors such as leaf position, time of day, sample storage time, plant age and form of fertilizer N.

A large field trial indicated that at 4 sampling dates (50, 60, 80 and 90 days after transplanting; DAT) and prior to sidedressing, xylem (R^2 = 0.73**) and petiole (R^2 = 0.86**) sap were strongly correlated to extractable NO_3-N and NH_4-N in the soil to a depth of 30 cm. Nitrate-N levels in xylem sap at 60 and 80 DAT and petiole sap at 50, 60 and 80 DAT were good predictors of harvestable fresh head yield. Maximum marketable fresh head yield (55 t/ha) was achieved with an initial N application of 300 kg N/ha over a growing period of 150 days in which 448 mm of drainage was estimated. At heading, on the 300 kg N ha^{-1}, soil mineral N levels were 75 kg N ha^{-1}, xylem sap concentration was 333 μg NO_3-N ml^{-1} and 1651 μg NO_3-N ml^{-1} in the petiole sap. This critical value for petiole sap is higher than that reported in the literature for cabbages. At petiole sap levels below the critical value, sidedressing with 100 kg N/ha as urea was required to achieve a similar yield as found with an initial application of 300 kg N ha^{-1} as calcium ammonium nitrate.

In a small scale field experiment, plant recovery (62-65%) of sidedressed

^{15}N labelled urea N did not differ between sidedressing rates (100 and 200 kg N). Total recovery of ^{15}N in the plant and soil was considered high (114 $\pm$ 0.9% and 90 $\pm$ 1.1%) for the respective rates.

Using the data obtained from the field trials, a simple model termed a "sidedressing model" was developed. The model specifically determines the amount of N fertilizer needed to be applied as a sidedressing at a critical time (heading) to obtain maximum yield. The model was validated, using the data from another N fertilizer field trial conducted in the following year. The model successfully predicted whether N sidedressing is required or not but only a limited validation could be made of the prediction rates.

The limitation of the sidedressing model of being site and season specific can be reduced by using simple submodels to predict the measured component which assessed N in cabbages at heading (N_h). One submodel used (the heat unit model) was modified by including data from 2-year trial results, to predict N_h and also provided a prediction of N uptake at maturity (N_y). Although not able to be validated in this study, the model shows potential for use by environmental administrators in predicting the likely effects of various growers practices in relation to identifying problems associated with NO_3-N in drinking water and in edible cabbage heads.

ACKNOWLEDGEMENTS

I am extremely grateful to:

Dr Paul Gregg and Dr Mike Hedley for their supervision, guidance, patience and friendship during my studies.

Other members of the Soil Science Department for valuable discussions and assistance during the work.

Dr Santiago Obien, director of the Philippine Rice Research Institute, for the encouragement to pursue postgraduate studies.

Ms Lee Heng and Mr Wichien Chatupote for assistance with computer work and final preparation of this thesis. Mr Donald Tambunan and other postgraduate students and all technicians in the Department for help with glasshouse and field work.

All Filipino friends particularly Mr and Ms Angel Carambas.

The Ministry of External Relations and Trade of New Zealand for the scholarship grant.

The National Tobacco Authority of the Philippines for the study leave.

Lastly, but most important, to my mother, brothers and sisters for their great moral support.

TABLE OF CONTENTS

CHAPTER 3

METHODS OF MEASURING SAP NITRATE CONCENTRATIONS IN CABBAGES

CHAPTER 4

FACTORS AFFECTING SAP NUTRIENT CONCENTRATIONS IN CABBAGES

CHAPTER 5

INFLUENCE OF FERTILIZER FORMS ON SAP NUTRIENT CONCENTRATIONS AND YIELD OF WINTER CABBAGES

CHAPTER 7

EFFICIENCY OF ^{15}N LABELLED UREA FERTILIZER APPLIED AS A SIDEDRESSING TO WINTER CABBAGES

CHAPTER 8

MODELLING THE NITROGEN FERTILIZER REQUIREMENTS OF WINTER CABBAGES

CHAPTER 9

LIST OF FIGURES

LIST OF TABLES