'The Maize Calculator' - a simple system for predicting fertiliser nitrogen requirements of maize

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Introduction

Fertiliser may comprise 10-15% of the total cost of producing a typical maize crop in New Zealand. For this reason alone optimising the amount of fertiliser applied to maize is important. In the North Island of New Zealand it is common to apply 200 kg N/ha to maize crops. Potential environmental concerns (from leaching losses of N) further underline the importance of applying only as much fertiliser as the crop will economically respond to.

To reliably optimise the marginal returns from fertiliser, it is necessary to quantify the relationship between fertiliser application and yield. That is often difficult, especially given that yield changes with factors such as sowing time, hybrid, planting density and location (e.g., Wilson *et al.*, 1995). Variations in yield due to hybrid and weather can be accounted for by potential yield models (Wilson *et al.*, 1995).

The objective of this paper is to demonstrate how marginal returns from fertiliser inputs can be optimised by combining a fertiliser response model with a potential yield model, suitably adjusted for planting density effects. The fertiliser response model, PARJIB, has been described in an accompanying paper (Reid, 1999). The potential yield model was described by Muchow *et al.* (1990) and Wilson *et al.* (1995). The combined model is called 'The Maize Calculator'.

Calculator Overview

The potential yield model was initially developed by Muchow *et al.* (1990) and modified for cool climate maize production by Wilson *et al.* (1995). Basically, the maize calculator calculates changes in green leaf area index as a function of thermal time, accounting for new leaf production and leaf senescence. These values are then used to calculate the amount of light intercepted by the crop, using a Beer-Lambert Law analogue. Daily light interception is used to calculate increments in crop dry matter, assuming that the value of radiation use efficiency (g dry matter produced per MJ light intercepted) differed between early and late growth, and was also reduced by cool temperatures. Finally, grain yield is calculated assuming that harvest index increases with thermal time after silking, up to a maximum of 0.5.

The nutrient response model (PARJIB) uses the estimates of potential yield to calculate the attainable yield. A key part of this process is to first adjust the potential yield estimate for planting density. To do this we built in a density response function into PARJIB. The parameters for this density function are calculated along with the other PARJIB parameters as part of the calibration process. Finally, although the maize calculator calculates yield its recommendations are expressed in terms of marginal returns from fertiliser. The returns are calculated using the yield response, the price of fertiliser and the expected value of the grain in $/t.

Calculator performance

The maize calculator was calibrated using information from a wide range of sources. An important source was a 1996-97 survey of maize paddocks in the North Island. These were commercial paddocks in the Waikato, Bay of Plenty, Gisborne, and Hawke's Bay. Soil types varied considerably and included alluvial soils (sandy loams, silt loams and clay loams), and volcanogenic soils (ash and pumice soils), as well as soils with significant features of both. At each location we set up monitoring plots where we took initial soil tests and applied different rates of N, P, K and Mg fertilisers. The main maize cultivar was P3730. We also took information from two field experiments conducted in 1997-98 on a Mangateretere silt loam near Hastings. These experiments included a wide range of populations, planting dates and fertiliser (N and P) applications. In all cases we used the standard soil tests (pH in water, bicarbonate-extractable P, exchangeable K and Mg) plus 'readily available N' (estimated by adding mineral N in the soil sample to the mineralisable N measured using Keeny and Bremner's (1966) anaerobic incubation at 40°C). Whatever the relative merits of alternative N indices, this is the only test for which the maize calculator has been calibrated.

Despite the wide range of conditions represented in the calibration data, the maize calculator calibrated very well (Fig. 1). The calibration root mean square error was 0.66 t/ha. When we regressed observed on simulated yield the slope was (1.01 ±0.065) and the intercept was (-0.1 ± 0.67). The maize calculator accounted for 83% of the observed variation in yield. Model calibration indicated that economic responses to P, K and Mg fertilisers would be rare in the North Island. It also indicated that soil pH can have a significant effect on yield - soil pH values less than 5.6 constrain yield and have an important effect on the response to fertiliser.

Using the Maize Calculator

The maize calculator has been programmed as stand-alone software for personal computers. It has modest data requirements - choice of cultivar, location, sowing date, planting density and a standard soil test with the inclusion of the 'readily available N' test. The latter is available from commercial soil testing laboratories in the North Island. The maize calculator also needs the price of fertiliser and the expected price for grain. The latter two inputs are important because if the cost of fertiliser increases, the amount of fertiliser required to achieve maximum marginal return drops. Conversely, if the price of grain increases, the amount of fertiliser required for maximum marginal return also rises.

To explore the differences due to cultivars, locations and seasons, users need only select the appropriate cultivars and locations from a list before typing in the sowing date. The maize calculator then estimates potential yield for the specified conditions. To calculate N fertiliser requirements, this estimate of potential yield is entered into the fertiliser model. The user enters the cost of N fertiliser and the price expected for grain. The maize calculator then works out the amount of fertiliser required to achieve for maximum marginal return.

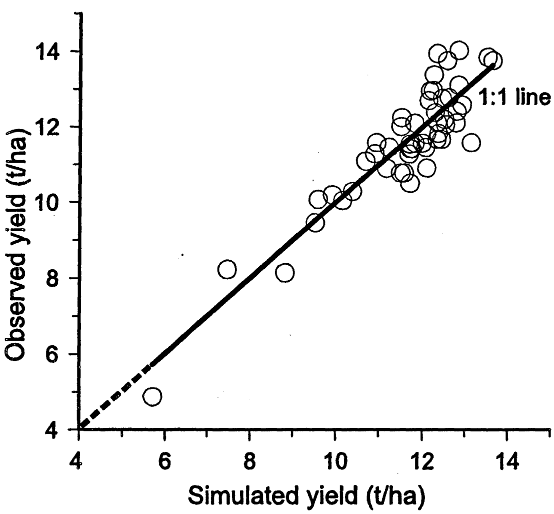

Figure 1. Calibration of the maize calculator. Simulated and observed yields are compared for sites in the Waikato, Bay of Plenty, Gisborne and Hawke's Bay.

Acknowledgements

This work was funded by the Foundation for Arable Research (FAR), the NZ Fertiliser Manufacturers Research Association, Heinz Watties Australasia Ltd, and the Ministry for the Environment. We are grateful to FAR, Ravensdown Fertiliser Cooperative, Genetic Technologies and a host of maize growers for their tangible support of this work.

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