Five Canterbury field trials were carried out in 2009-10, to determine the effect of plant population on dry matter, grain yield, stem diameter and profitability of maize silage production.

Experimental design and measurements
The trial sites were sown with a commercial planter at the same time as the surrounding commercial crop. The experimental design was a randomised block design of ten sowing rates replicated twice, in plots 25 m by 16 rows at a row spacing of 0.76 m.

At Southbridge and Fairton the targeted sowing rates were 50,000, 65,000, 80,000, 95,000, 110,000, 125,000, 140,000, 155,000, 170,000 and 185,000 plants/ha. At Pendarves, Rangitata and Winchmore the targeted sowing rates were 70,000, 85,000, 100,000, 115,000, 130,000, 145,000, 160,000, 175,000, 190,000 and 205,000 plants/ha.

The harvest samples were cut from 2 m of the two middle rows of each plot. The plants were cut 5 cm above ground level and the plant numbers and total fresh weight were recorded. A three plant sub-sample was split into leaf, stem and ear samples for analysis.

Table 1. Site Information.

<table>
<thead>
<tr>
<th>Site</th>
<th>Southbridge</th>
<th>Fairton</th>
<th>Rangitata</th>
<th>Pendarves</th>
<th>Winchmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type</td>
<td>Tai tapu silt loam</td>
<td>lismore stony silt loam</td>
<td>eyre stony silt loam</td>
<td>templeton silt loam</td>
<td>lismore stony</td>
</tr>
<tr>
<td>Plant Date</td>
<td>16 October</td>
<td>21 October</td>
<td>5 November</td>
<td>7 November</td>
<td>10 November</td>
</tr>
<tr>
<td>CRM</td>
<td>88</td>
<td>88</td>
<td>82</td>
<td>78</td>
<td>84</td>
</tr>
<tr>
<td>Total N applied Kg/ha</td>
<td>111</td>
<td>200</td>
<td>NA</td>
<td>132</td>
<td>183</td>
</tr>
<tr>
<td>Irrigation</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Introduction
Choosing an appropriate plant population is one key to maximising profitable maize silage production. Maize yield increases with increasing plant population because a dense, closed crop canopy maximises the interception of light. However, the yield increase eventually reaches a plateau as shading in the crop increases and increasing the population beyond this point is uneconomic.

Maize silage crops are typically sown between 100,000 and 115,000 plants/ha, but there are a number of reasons why the optimum plant population may be higher in South Island regions.

1. Canterbury maize growers generally choose short maturity hybrids to fit their shorter growing season. These typically yield less than long season hybrids because there is less opportunity to intercept sunlight.

2. Cool spring air temperatures in South Island locations mean leaf area development is slower than in northern locations. Crops at higher plant populations will reach canopy closure faster for maximum light interception.

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The harvest samples were cut from 2 m of the two middle rows of each plot. The plants were cut 5 cm above ground level and the plant numbers and total fresh weight were recorded. A three plant sub-sample was split into leaf, stem...
and rachis, and grain components, which were weighed fresh, then dried in a fan-forced oven at 90°C for three days. The dried samples were weighed and the results used to calculate silage yield, grain harvest index and silage DM content. Stem diameters were measured at the widest part of the stems. At Fairton, Rangitata, Winchmore and Pendarves, the measurements were made 20 mm below the third node down from the top cob whereas at Southbridge they were measured 20 mm down from the fifth node.

Results and discussion

Dry matter yield
At all sites, silage yield significantly increased as the plant population increased. At all sites, except Pendarves, the increases were exponential, up to a population of about 140,000 plants/ha, after which they flattened off. At Pendarves the yield increase flattened off at about 180,000 plants/ha. The impact of plant population on yield was considerably different between sites, this was attributable to site and environmental differences. The highest yielding sites were Southbridge and Winchmore. Rangitata was the lowest yielding site, possibly due to a dry summer and problems with fat hen (Chenopodium album) and volunteer potatoes within the trial.

Economics
Increasing sowing rate will increase yield but with an increase in seed cost. Maize seed is expensive and a dense crop may suffer from more disease, water stress and nutrient deficiencies. Any decision to increase the plant population must be based on the trade-off between the increase in the silage value and the increase in the seed costs. In this trial the population and yield data from each site was used to fit and exponential regression equation, relating yield to population

Economic analysis to find optimum populations for each site used the following equations and 2009-10 crop production costs, where $x = \text{plant population}$ and $y = \text{calculated yield}$

Southbridge
\[ y = 27541 \times (1 - \exp(-0.0000274 \times x)) \]

Fairton
\[ y = 24940 \times (1 - \exp(-0.0000245 \times x)) \]

Rangitata
\[ y = 20502 \times (1 - \exp(-0.0000186 \times x)) \]

Pendarves
\[ y = 26722 \times (1 - \exp(-0.0000144 \times x)) \]

Winchmore
\[ y = 28107 \times (1 - \exp(-0.0000199 \times x)) \]

Silage value $0.22/\text{kg}$
Bag of 80,000 seeds $460$
All costs associated with the crop $1300/\text{ha}$
Harvest costs $1400/\text{ha}$

Grain harvest index and dry matter %
Grain harvest index is a measure of the proportion of grain to plant DM at harvest, this is an important measure for silage quality as the grain contains the most digestible energy. As plant population increases, cob size decreases; at the Fairton, Southbridge and Pendarves, the grain harvest index decreased slightly with increasing population, at Fairton increasing the plant population from 120,000 to 130,000 plants/ha, reduced the grain yield by 59 kg/ha. Similarly the dry matter % also decreased slightly with increasing population, probably related to the denser canopy having reduced air flow and/or higher humidity, this has implications for maturity times, with crops at higher populations taking longer to reach optimal maturity.

Stem diameter
Increasing the plant population caused a significant decrease in mean stem diameter at all trial sites. Thinner stems could increase the risk of lodging, however no lodging was observed at any of the trial sites. Results are presented in table 3.

<table>
<thead>
<tr>
<th>Trial site</th>
<th>Stem diameter at 100,000 pl/ha (mm)</th>
<th>Stem diameter at 150,000 pl/ha (mm)</th>
<th>Stem diameter decrease (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbridge</td>
<td>23.2</td>
<td>20.0</td>
<td>-3.2</td>
</tr>
<tr>
<td>Fairton</td>
<td>22.0</td>
<td>17.9</td>
<td>-4.1</td>
</tr>
<tr>
<td>Rangitata</td>
<td>18.3</td>
<td>14.6</td>
<td>-3.7</td>
</tr>
<tr>
<td>Pendarves</td>
<td>20.8</td>
<td>19.1</td>
<td>-1.7</td>
</tr>
<tr>
<td>Winchmore</td>
<td>23.3</td>
<td>19.4</td>
<td>-3.9</td>
</tr>
</tbody>
</table>
Hybrid maturity and planting temperature
There was a strong relationship between CRM of the hybrid in each trial and the economically optimum plant population. Short duration hybrids benefit from an increased plant population because they are less leafy than longer duration hybrids. Higher plant populations maximise the amount of solar radiation interception by ensuring canopy cover is achieved as quickly as possible.

Conclusions
The results from these trials show that maize silage yields in Canterbury can be increased by increasing the plant population to around 130,000–150,000 plants/ha. However, farmers also need to consider other factors that affect yield, such as hybrid choice, sowing date, environment and management practices to get the benefits from a higher population and the additional cost of seed.

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