Forage Brassica Crops for Pastoral Systems

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Plant and Food Research
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FBDG Project Objectives

• Increase the overall productivity of NZ’s pastoral systems by improving the contribution by forage brassica crops
• Better crop establishment
  o Poor establishment is a common cause of poor performance
• Higher, more reliable yields
  o Yields are extremely variable, and many crops yield well below their potential
• Higher rate of pasture renewal
  o To encourage use of brassicas during transition to enable faster adoption of improved pasture cultivars
• Fit brassicas into pastoral systems
  o Ensure that brassicas pay their way in the systems

Features of brassica production

• Summer and winter brassicas are grown widely to supplement pastures in NZ’s pastoral systems
• About 300,000 ha are grown each year:
  o By far the largest scale crop type in NZ
• Brassicas are important for their:
  o Potential to produce high quality forage
  o Role as break crops for controlling pasture weeds, pests and diseases
  …however, performance from brassicas has been extremely variable

What was learnt

– Field trials showed visual effects of fertiliser application
– High potential of turnips for summer feed
  • Suggested that more work be done on animal performance on turnips
– Need to monitor the biomass utilised as well as the kg/ha feed grown
  • Palatability, digestibility and feed management are important

What was learnt

• There were many poor crops
  o Mostly caused by poor weed and pest control, and poor establishment
• Farmers often mismanaged fertiliser applications (rates and timing) and used poor practices with various drill type
• Biosecurity – need more knowledge about spread of disease
• Need to validate the down the spout vs broadcast debate
  – Is there a species difference here?
• Nutritional issues
  – What quality components need to be balanced to ensure good responses on brassicas?
• Utilisation issue
  – How much is actually lost with poor animal and paddock management
Key themes for research

- Crop establishment
  - Direct drill or cultivate?
  - Cultivate then drill or broadcast
  - Fertiliser quantity
  - Target plant populations (brassicas self-thin if sown too thickly)
- Fertiliser placement
- Crop sequences/rotations
- How to assess yield
- Utilisation of crops

1. Species and Cultivars

Species and Cultivars

- Brassicas used for forage in NZ are classified into five types: swedes, kale, rape, turnips and leaf turnips
- Different species and cultivars within each species have characteristics that suit different farming systems
- All are biennials
  - They grow vegetatively in the first season (storing yield in bulbs or stems)
  - And produce seed in the second season

<table>
<thead>
<tr>
<th>Common name</th>
<th>Latin name</th>
<th>Growth habit</th>
<th>Vegetative description</th>
</tr>
</thead>
</table>
| Leaf turnip (turnip-rape) | Brassica rapa; syn. B. campestris | Non-bulb producing | - Fleshy bulb
- No neck
- Yellow fleshed (hard)
- White fleshed (soft) |
| Bulb turnips | Brassica rapa; syn. B. campestris | Fleshy bulb | - Large swollen stem
- Stems - woody outer layer, soft fleshy marrow |
| Swedes | Brassica napus spp. napobrassica | Numerous leaves | - Fleshy bulb
- Obvious neck
- White or yellow fleshed |
| Rape | Brassica napus spp biennis | Fibrous stem | - Fleshy bulb |

Winter Feed Options

a. Kale

- Kale is the traditional winter feed crop. (can also be used as a summer feed and is able to regrow after light grazing) with high yield potential
  - Deep root system and good tolerance to drought.
  - Tolerant to most insect pests, resistant to clubroot and dry rot
- Usually sown between October and January
  - Optimum is around 18-26 weeks and it is usually single-grazed during the period from about late May to mid-July
  - Yield is variable, depending on crop management and environmental conditions
  - Responds strongly to availability of water and nutrients yields
  - Stem quality and palatability vary with plant population
  - Quality is usually better with smaller stems at higher populations

- Short cv. Kestrel
  - Generally sown later because slightly faster maturing
  - Higher leaf:stem ratio, higher whole-plant digestibility and produce lower yields (up to about 12,000 kg DM/ha) than taller types
  - Suited to grazing by sheep and lambs because of their shorter height
- Intermediate cv. Sovereign, Proteor and Regal
  - Intermediate height with high leaf yield and a high leaf:stem ratio
  - Produce yields up to about 15,000 kg DM/ha
  - Suitable for grazing in sheep and cattle systems
- Giant cv. Gruner, Rawera and Caledonian
  - Tall (sometimes up to 2m) means suitable only for cattle
  - Lower leaf:stem ratio, lower whole-plant digestibility and produce higher yields (up to about 171 DM/ha) than shorter types
b. Swedes

- Less tolerant to drought than kale
  - performs best in cool, moist environments
- Most cultivars have some susceptibility to clubroot and dry rot
  - therefore only be grown as a first brassica crop
- Swedes are usually sown from mid November – end December
  - yields above 20 t DM/ha are possible in favourable conditions
- Animal performance is usually better on swedes than on kale
  - the feed quality characteristics of the leaf and bulb are more complementary than the leaf and stem of kale
  - whole-plant digestibility is higher in swedes
  - high utilisation can usually be achieved

<table>
<thead>
<tr>
<th>Early maturing types</th>
<th>cv. Major Plus and Dominion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Both are yellow-flesh cultivars with soft bulbs which makes them suitable for grazing by young stock</td>
</tr>
<tr>
<td></td>
<td>They have less disease tolerance than newer cultivars like Aparima Gold, but produce 10-12% higher yields than older ones like Doon Major</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Late maturing types</th>
<th>cv. Aparima Gold and Winton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aparima Gold is a yellow-flesh cultivar while Winton has white flesh and both have a higher leaf:bulb ratio and better tolerance to dry rot and clubroot than older cultivars</td>
<td></td>
</tr>
</tbody>
</table>

b. Swedes

Early and late maturing types can be complementary if sown together

Animals adapt faster if they graze the faster-maturing, soft-flesh ones first

- Early maturing types cv. Major Plus and Dominion
  - Both are yellow-flesh cultivars with soft bulbs which makes them suitable for grazing by young stock
  - They have less disease tolerance than newer cultivars like Aparima Gold, but produce 10-12% higher yields than older ones like Doon Major
- Late maturing types cv. Aparima Gold and Winton
  - Aparima Gold is a yellow-flesh cultivar while Winton has white flesh and both have a higher leaf:bulb ratio and better tolerance to dry rot and clubroot than older cultivars

c. Rape and turnips

- Although they are principally summer/autumn feeds, Green Globe turnips and Goliath rape are also good winter options in some circumstances
- New cultivars with good frost resistance are suited for feeding later in the autumn and winter

Turnips

Dutch type early – late -
York Globe Green globe

Breeding objectives

- Kale
  - More leaf, softer stems & low SMCO
- Rape
  - Aphid resistance, good acceptability
- Swedes
  - Clubroot and dry rot resistant lines
- Turnips
  - TuMV resistance

Low SMCO selection

- Kale anaemia / Red water disease
- s-methyl cysteine sulfoxide
  - non-protein amino acid
  - converted to dimethyl disulfide in ruminants
- causes haemolytic anaemia
Rape breeding

• Aphid resistance
• Good acceptability
• and good edibility

Good aphid resistance - transferred from kale

Aphid susceptible control

2. Establishment

Sowing Methods

Direct drill
Coulter drill
Ridging
Roller drill
Broadcasting
Specialist drills
Sowing rate

- Variation in seed size within a line can alter the total number of viable seeds per unit weight
- Sowing rate depends on species and sowing method

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sowing Method</th>
<th>Sowing rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnips</td>
<td>Ridged Drilled 15 cm rows</td>
<td>0.5 - 0.7</td>
</tr>
<tr>
<td></td>
<td>Broadcast</td>
<td>0.75 - 1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0 - 3.0</td>
</tr>
<tr>
<td>Swedes</td>
<td>Ridged Drilled (15 cm rows)</td>
<td>0.5 - 0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.75 - 1.0</td>
</tr>
<tr>
<td>Kale</td>
<td>Ridged Drilled 15 cm rows</td>
<td>1.7 - 3.5</td>
</tr>
<tr>
<td></td>
<td>Broadcast</td>
<td>3.0 - 5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Rape</td>
<td>Drilled 15 cm rows</td>
<td>2.5 - 3.0</td>
</tr>
<tr>
<td>Leaf turnips</td>
<td>Drilled 15 cm rows</td>
<td>3.0 - 4.0</td>
</tr>
<tr>
<td></td>
<td>Broadcast</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Sowing depth

- Numerous studies have shown that the optimum sowing depth of brassicas is 1-1.5 cm
- Seed broadcast on a dry soil surface will not germinate until substantial rain (20mm) has fallen
- Deeper sown (3 cm+) seeds may fail to emerge or emergence will be staggered
- Rapid emergence of brassica seed is desirable for weed control by the crop

3. Soil Fertility and Fertiliser Management
Principles

- Brassicas have large mineral nutrient requirements
- They are grown in a wide range of conditions:
  - Often as break crops in pasture renewal
  - Sometimes in lower fertility following run-out pastures or other crops
  - Sometimes in high fertility conditions
- Crops respond to total nutrient availability from soil and fertiliser
- Variable soil fertility and potential yield mean that every crop has a different fertiliser requirement and yield response

Macronutrients

- P:
  - Requirement is quite low (0 to 50 kg/ha) depending on Olsen P level. No response of Olsen P >20
  - Crop establishment and yield respond when soil P is low
  - P is most effective applied down-the-spout at sowing, but no response if Olsen P at 13 (kale)
- K:
  - Requirement for K is high (<100 to >400 kg/ha)
  - But yield seldom responds to K application
  - Most NZ soils can supply enough K to meet crop needs
  - Exceptions are volcanic soils and some others with low TBK
- N:
  - Requirement for N is high (<190 to >400 kg/ha)
  - Yield usually responds strongly to N application at sowing
- S:
  - Requirement for S is moderate (up to 70 kg/ha)
  - Yield seldom responds to S application

Nutrient Supply From Soil

- The soil’s ability to supply nutrients depends on its fertility
- A soil test indicates the level of each nutrient in the soil

<table>
<thead>
<tr>
<th>Test/Nutrient</th>
<th>1 Low</th>
<th>2 Medium</th>
<th>3 High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available N (kg/ha)</td>
<td>&lt;80</td>
<td>80 to 160</td>
<td>&gt;160</td>
</tr>
<tr>
<td>Olsen P</td>
<td>&lt;15</td>
<td>15 to 25</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Soil test K</td>
<td>&lt;4</td>
<td>4 to 8</td>
<td>&gt;8</td>
</tr>
<tr>
<td>Sulphate-S</td>
<td>&lt;3</td>
<td>3 to 9</td>
<td>&gt;9</td>
</tr>
<tr>
<td>Soil test Mg</td>
<td>&lt;3</td>
<td>3 to 8</td>
<td>&gt;8</td>
</tr>
</tbody>
</table>

1. Response to fertiliser application very likely
2. Response may occur
3. Response unlikely

Fertiliser Guidelines

Pre-sowing

- Measure soil pH well before sowing
- The optimum pH for brassicas is 6.2. It should be at least 5.6, and ideally between 5.8 and 6.2
- If pH is low, apply lime
- Lime at 1 t/ha will increase pH by ~0.1 on most soils
- pH adjustment takes time so, ideally, lime should be applied at least a year before sowing a brassica crop
- Brassica calculators can be used to schedule fertiliser requirements

At sowing

- Estimate the crop’s expected yield
- Calculate the demand for each nutrient (see table):
  - Expected yield x nutrient content
- Get a forage brassica soil test
- Estimate the soil’s ability to supply each nutrient
- Estimate the amount of each nutrient (type and rate per ha) needed from fertiliser to reach the target yield
- Work out a mix of fertilisers:
  - Apply all except N down-the-spout at sowing
  - Broadcasting is much less effective (especially for P)
  - Can include some starter N in the sowing mix

With and Without P at Sowing
### Macronutrient Requirements

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (t/ha)</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Turnip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>6</td>
<td>32</td>
<td>11</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>12</td>
<td>64</td>
<td>23</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>150</td>
<td>18</td>
<td>96</td>
<td>34</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>200</td>
<td>24</td>
<td>128</td>
<td>46</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Typical % Nutrient Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>Nutrient uptake (kg/ha)</td>
</tr>
</tbody>
</table>

### Micronutrients

- **Boron (B):**
  - Minimum soil test value is 0.8 mg/kg
  - Crop content should be ~26 mg/kg
  - Requirement is 50 to 400 g/ha for 2 to 15 t/ha yield
  - Apply B at 1.5 kg/ha to brassicas

- **Copper (Cu):**
  - Minimum soil test value is 0.8 mg/kg
  - Crop content should be ~3.3 mg/kg
  - Requirement is 7 to 45 g/ha for 2 to 15 t/ha yield
  - Applying Cu in fertiliser doesn’t increase Cu uptake

- **Cobalt (Co):**
  - Minimum soil test value is 1.0 mg/kg
  - Crop content should be ~0.07 mg/kg
  - Requirement is <1 g/ha for all crops
  - Molybdenum (Mo)
  - Critical for leaf brassicas

### Animal Health Issues

- Avoid potential animal health problems which can be caused by too much N or S
- High nitrate content in forage can cause poisoning in grazing animals
  - Check for nitrate content before grazing
- SMCO is an S compound in forage brassicas (particularly kale) which can cause animal disorders
  - Reduce risk by applying fertiliser without S
  - Don’t apply too much N when soil S is high

### 4. Feeding

**Animal production on forage brassicas**

- Brassicas can make up 100% of diet but best to mix with other forages
- Milking dairy cows should have no more than 30% of the diet
- Sheep can be fed at 90-100% of the diet – need a long adaptation period for maximum benefit
- Brassicas are low in fibre and high in sugars, increasing the risk of rumen acidosis

**Factors related to poor performance on brassicas**

- High water content
- Low NDF
- Anti-nutritional compounds
- Low forage intake
- High plant sulphur levels interfere with other trace elements, e.g. Cu and Se
- Mineral imbalance, e.g. Ca and P
- Feed hay or straw to supplement the low fibre
Low Fibre Content

- Forage brassicas contain little effective fibre, i.e. fibre that encourages the animal to chew
- Feed hay or straw to supplement the low fibre to
  - Increase saliva production
  - Stabilise gut function
  - Reduce passage
  - Improve animal performance
  - Minimise anti-nutritional problems
  - Dilute SMCO, nitrates and glucosinolates

Anti-Nutritional Factors

- Several compounds in brassicas which can potentially limit production or cause death to livestock
- In most cases they can be managed by good husbandry
  - SMCO (S-methyl cysteine sulphoxide)
    - Causes red water
    - Depresses intake
    - High in flowering crops
    - Low Cu and Se accentuates SMCO effects
  - Glucosinolates
    - Influences thyroid metabolism
    - Effects can be managed with supplementation

Feeding hoggets on Swedes

- Hoggets offered ad-lib hay (+ Swedes) grew 50% heavier than the hoggets offered hay for 2 hours per day
- The growth rates for the high quality lucerne and average quality meadow hay (+ swedes) were similar if offered for 2 hours per day
- Hoggets fed swedes only had the lowest liveweight gain of the groups.

Selective feeding

1:2 swede:rape  4:1
<table>
<thead>
<tr>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Crop choice (species &amp; cultivar) should be based on farming system: cattle vs. sheep, dryland vs irrigated &amp; time feed is needed</td>
</tr>
<tr>
<td>• Crop establishment is determined by sowing rate, method &amp; depth (all issues under farmer control)</td>
</tr>
<tr>
<td>• Crop yield largely depends on soil nutrient management; key nutrients are N &amp; P</td>
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<tr>
<td>• Feed allocation depends on paddock area, estimated yield, crop quality and expected utilisation</td>
</tr>
<tr>
<td>• Brassicas with low fibre and high sugar content leads to animal health issues: bloating, nitrate poisoning, etc</td>
</tr>
<tr>
<td>• Anti-nutritional compounds also impact on intake and hence body conditioning</td>
</tr>
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</table>