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FERTILISER RECOMENDATION

For

Lanercost Farming Ltd 2018
2018

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LanercostFertReco2018

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Brief

Lanercost Farming Ltd 2018 has asked agKnowledge Ltd to assess the current soil fertility of the Lanercost farm and provide independent advice on the fertiliser requirements for the next 12 months, taking into account the goals set for the farm.

Background

When developing a fertiliser plan we determine, in the first instance, the amounts of nutrients and hence the least-cost fertiliser required to reach the *full economic potential (maximum profit) of the farm irrespective of the cost of the fertiliser inputs required to so*. We do this because we believe that farmers should know if there is any unrealised potential. We then modify the fertiliser plan to accommodate at the specific circumstances of the farm.

To this end you have instructed agKnowledge as follows:

1. The fertiliser budget is constrained to approximately $65,000 annually.

Background

Capital fertiliser inputs are normally a one-off. Once the optimal nutrient levels (i.e. the levels which optimize long-term profitability) have been achieved a maintenance program will be commenced to maintain the optimal soil tests levels. Typically a maintenance program costs 30-50% less than a capital program (about $10/su).

Farm Description

This 1200 ha property is situated at Ferniehurst in North Canterbury and comprises sheep and beef operations. The topography of the farm ranges from flat through to steep hill-country. The elevation ranges from 55 to 360 meters and the annual rainfall is approximately 860 mm with summer dry spells. The prevailing wind is from the west and the coast is 12 km to the east.

[**Important disclaimer:** This report does not constitute a NUTRIENT MANAGEMENT PLAN as defined by most by Regional Councils. It does not consider the economic outcomes or the environmental consequences of the recommended fertiliser policies and practices. For a full Nutrient Management Plan call agKnowledge Ltd on 0800 33 73 46, or email to info@agknowledge.co.nz, or write to PO Box 9147, Hamilton]

Farm Goals

The goals you have set for your farm for the next 5 years are:

Farm Goals	
Production	Increase production
Economic	Maximise profit

Pasture Composition and Quality

Background
Pasture quality and composition, and hence the likely pasture productivity, are related to the underlying soil fertility and before the advent of routine soil testing visual assessment of pastures (called Fertility Index) was used regularly as a means of assessing soil fertility.

In our legume-based pastoral systems, soil fertility (the amounts of plant nutrients in the soil) is variable over time and space. This is because animals do not return nutrients (as in dung and urine) evenly – large accumulations of nutrients occur in excreta patches and in areas where animals camp or congregate (around water troughs, hedges and shelter, flatter areas on the top or the bottom of hillsides).

For this reason it is very easy to get inflated soil test levels which are not representative of the whole landscape. For example a soil sample generally comprises 15-20 soil cores (0-75 mm deep) and it requires only one soil core from an excreta patch to inflate the soil test reading and, in particular, the soil K levels.

For this reason agKnowledge Ltd uses an abbreviated version of the Fertility Index System to visually assess pasture quality and composition as a tool to ground-proof soil tests. If there is a discrepancy between the soil tests levels and the visual assessment then invariably it is the soil tests, which are incorrect.

A 10-point pasture rating system is used. A rating of 9-10 is excellent, meaning that the clover is vigorous and comprises about 30% to 40% of the sward and that the companion grass is predominantly vigorous, dark-green ryegrass. The excreta patches (i.e. dung and urine) are not obvious. At the other extreme, pastures rating 1-2 have low clover content (< 5%) with poor vigour and small leaves and the companion grasses are low fertility types such as browntop. Excreta patches are very prominent and the pastures between these patches are brownish-yellow with abundant flat weeds, low fertiliser legumes and grasses showing poor vigour.

Assessment

At the time of the farm visit (10 July 2018) the pasture composition and quality of each block was rated as follows:

Block	Rating[1]	Description[1]	Implications[1]
Flats	4-6	Clover content 10-30%, response to dung and urine; excreta patches very obvious; 50% ryegrass.	Possible P, K or S deficiency

Downs	4-6	Clover content less than 5%; excreta patches very obvious; rubbish grass species.	Possible P, K, S, Mo or pH deficiency
Hill	1-2	Clover content less than 5%, response to dung; excreta patches very obvious; rubbish grass species and moss.	Possible P, S or pH deficiency

Note: 1) Visual assessment of pastures is less reliable when they are under stress (moisture/wet/cold)

These observations are consistent with the pasture nutrient analyses and the soil nutrient levels (see later).

Pasture Nutrient Analyses

Background

There are two reasons for taking pasture samples: Clover-only samples are analysed to ensure that there are no nutrients limiting clover growth. The important nutrients are: P, K, S, Mg, B, Cu and Mo. Mixed-pastures samples are analysed to determine whether the pasture has adequate levels of those nutrients required for optimal animal health, especially Mg, Na, Cu, Co, Mo and Se. Pasture samples are best collected during periods of active growth, normally the spring or autumn. Plant stress due to lack of moisture or cold conditions can give results which are difficult to interpret.

Two clover-only samples from the Flats block were analysed on 10 July 2017. The key conclusions from these results, with respect to clover production are:

1. The concentrations of P were low in one sample.
2. The concentrations of Mg were low in one sample.
3. The concentrations of K and S were extremely deficient on both samples.
4. The concentrations of Mo, B and Cu were optimal for maximum clover growth.

One clover-only sample from the Downs block was analysed on 10 July 2018. Note that clover was gathered from stock camps, which may inflate the results. The key conclusions from these results, with respect to clover production are:

1. The concentrations of P were low.
2. The concentrations S were extremely deficient.
3. The concentrations of K, Mg, Mo, B and Cu were optimal for maximum clover growth.

Soil Fertility

Background

Ideally soil tests should be taken from a farm every one to two years from the same sampling transects and at the same time of the year. The transects should represent all the various blocks on the farm – that is areas of different slope (easy, rolling or flat), soil group (sedimentary, volcanic, pumice, peat, podzol or sand), land use (grazing, cropping including silage and hay, runoff, or effluent) or past fertiliser history, as indicated by the current soil tests.

This farm has a poor history of soil testing; regular soil tests have not been taken from the same transects at the same time of the year. It is recommended that a comprehensive and robust soil testing protocol is established and maintained for this farm.

At the time of the farm visit (10 July 2018) soil samples (13) were collected from representative areas on the farm. Based on these results and other available information the farm can be divided into 3 blocks based on land use, topography, soil group or current soil nutrient levels as follows:

Flats Block: comprising flat land on sedimentary soils (approximately 300 ha).

Downs Block: comprising predominantly easy hill country on sedimentary soils (approximately 450 ha).

Hill Block: comprising predominantly easy hill country on sedimentary soils (approximately 300 ha).

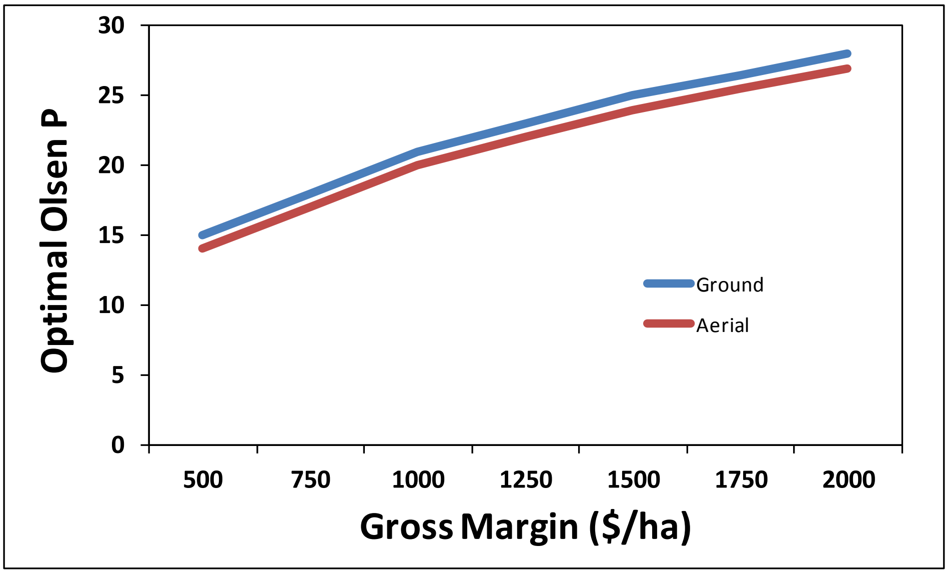
Optimal Soil Test Levels

Background

Phosphorus (P) is not only the main driver of the pasture production in our legume-based system, but it is also the most expensive nutrient. The agKnowledge philosophy is therefore to bring all the other nutrients to their biological optimum (i.e. for maximum pasture production) and then optimise the soil P level (Olsen P) for maximum economic return (profit), taking into account your goals in relation to production and economics.

The major factors affecting the economic optimal Olsen P are a) the biological efficiency of the farm and a good measure of this is the gross margin (GM) (the gross income minus the variable costs which includes animal health, supplements and power) and b) the cost of fertiliser on the ground.

The graph below shows the relationship between the economic optimal Olsen P and gross margin for both ground spread and aerial application, assuming typical costs.



From the information provided it is assumed that the average gross margin for the farm (i.e. averaged over all animal classes) is about $110/SU. Applying this to the graph above the optimal Olsen P ranges for the blocks are as follows:

Block[1]	Approximate stocking rate (SU/ha)	Approximate gross margin ($/ha)	Optimal Olsen P range
Flats & Downs	10-12	1210	20-25
Hill Block	4-5	1100	13-17

Note that the Downs block is currently carrying 5-6 SU/ha; however, because the intention is to lift production to that of the Flats block (10-12 SU/ha), the optimal P will be the same as the Flats block.

The most recent soil test results from the farm are given below relative to the relevant economical optimal Olsen P levels, and the biological optimal levels for pH, K, S, Mg and Na:

Block[1]	Olsen P	K	Sulphate S	Organic S	Mg	Na	pH
Flats	21	6	6	5	24	5	5.8
Downs	9	4	5	4	23	6	5.5
Hill	12	9	2	3	39	5	5.6
Optimal[2]	*20 - 25 (13 -17)[3]*	*7 - 10*	*10 - 12*	*10 - 12*	*8 - 10 (25 -30)[4]*	*3 - 4*	*5.8 - 6.0 (5.5 -5.6)[5]*

Notes:
1) Note that where more than one sample is collected per block the average is given.
2) The optimal ranges required to maximize long-term profitability.
3) The range in brackets is the economic optimal Olsen P range for the Hill block.
4) The range in brackets is the requirement for animal health.

5) The range in brackets is that required to maximise profitability in the long-term where lime has to be flown on.

Trends in soil fertility

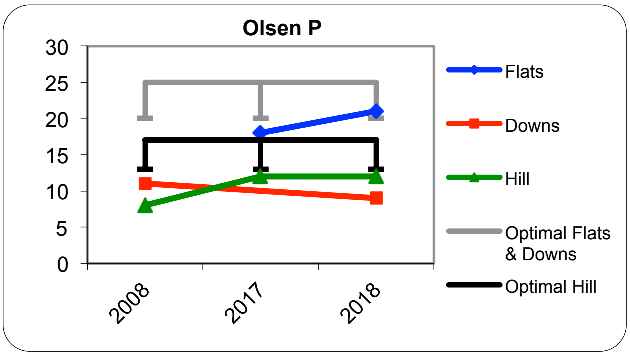
Background

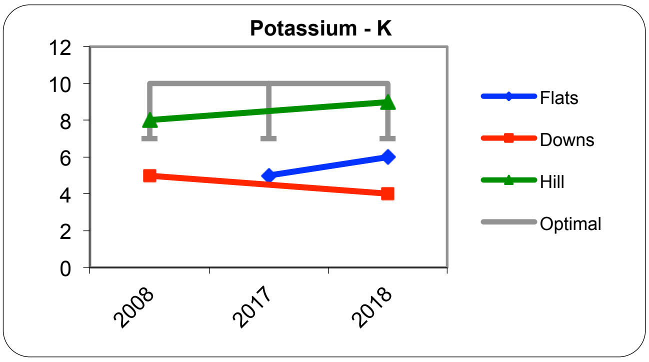
In our legume-based pastoral systems, soil fertility (the amounts of plant nutrients in the soil) is variable over space. This is because animals do not return nutrients (as in dung and urine) evenly – large accumulations of nutrients occur in excreta patches and in areas where animals camp or congregate (around troughs, hedges and trees, flatter areas on the top or the bottom of hillsides).

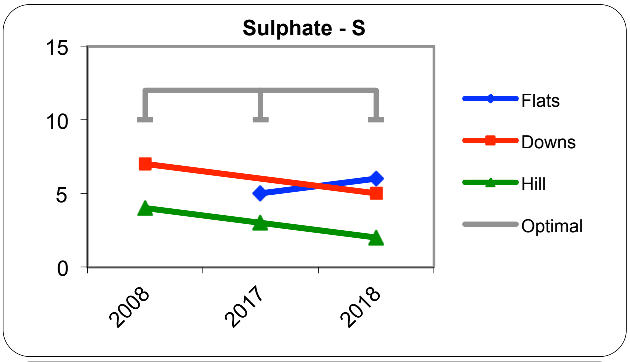
As a consequence the normal variability in soil test levels, assuming the soil samples have been correctly taken, are: soil pH and organic S (+/-10-15%), Olsen P, Quick Tests Ca, Mg and Na (+/- 15-20%), sulphate S and Quick test K (25-30%). For this reason there is often a lot of 'noise' is soil test data. It is for this reason that the trends over time are a more reliable means of determining the true soil fertility status of the farm.

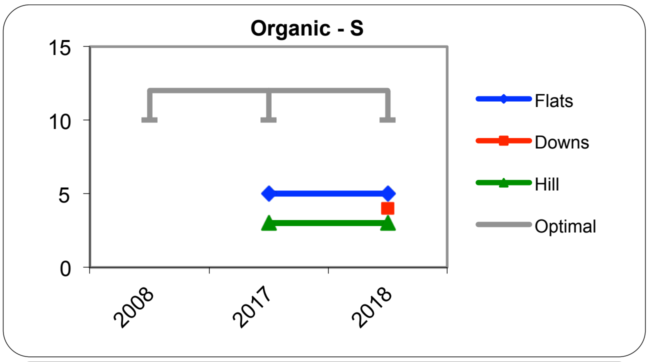
For the same reason it is very important that the soil testing transects are carefully chosen to avoid camping areas and that soil cores (there are typically 15-20 soil cores in one soil sample) are not taken from excreta patches. One soil core from a dung or urine patch will result in greatly inflated soil test levels which do not represent the true soil fertility on the farm.

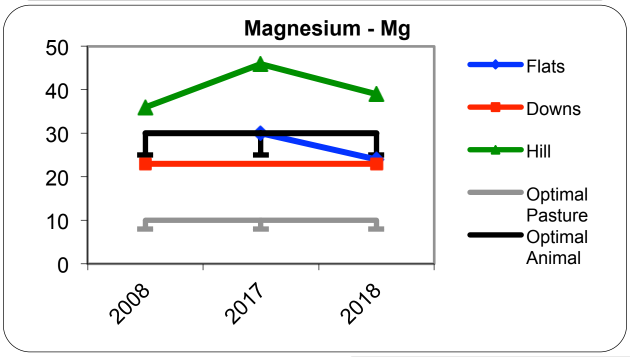
The trends in the average soil test levels for each block, relative to the optimal levels (shown as greyscale bars) are given below:

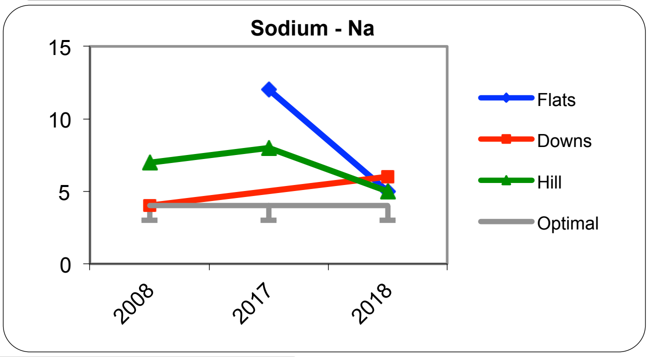


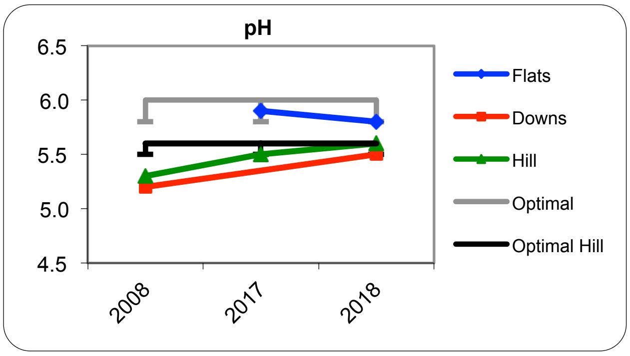












The key points from this analysis are:

1. **Olsen P:** The levels on the Flats block are within, the Downs block is below, and the Hills block slightly below, the respective economic optimal ranges.
2. **Soil K:** The levels on the Flats and Downs blocks are below, and the Hill block is within, the biological optimal range.
3. **Soil Sulphate (immediately available S):** The levels on all blocks are below the biological optimal range.
4. **Organic S (long-term S supply):** This is the largest and therefore the most important pool of plant available S. The levels on all blocks are below the biological optimal range.
5. **Soil Mg:** The levels on all blocks are above the optimal range for maximum pasture production. The Flats and Downs blocks are slightly below, and the Hill block above, the optimal range for animal health.

6. **Soil Na:** The levels on all blocks are above the optimal range for animal health (note that Na is not required for plant growth).
7. **Soil pH:** The levels on the Flats and Hill blocks are within, and the Downs block below, the respective optimal ranges.

These results indicate that P (Downs and Hill blocks), K (Flats and Downs blocks), S (all blocks), and pH (Downs block) are limiting pasture production and in particular clover production on this farm. These results are consistent with 1) the visual symptoms of nutrient stress in the pastures, as noted previously, and 2) the pasture nutrient analyses, as noted earlier.

Nutrient Strategies

Based on the above and assuming 1) that there are no constraints on the fertiliser budget and 2) the intention is to optimise the productivity (i.e. long-term profits) of the farm as soon as possible the following strategies are recommended.

Nutrient Strategy[1, 2 & 3]					
Block	**P**	**K**	**S**	**Mg**	**Lime**
Flats	Maintenance	Capital	Capital	Nil	No
Downs	Capital	Capital	Capital	Nil	Yes
Hill	Maintenance	Nil	Capital	Nil	No

Notes: 1) Capital P, K or Mg refers to inputs over and above maintenance, designed to increase the soil nutrient levels.
2) Maintenance is the amount of P, K, S or Mg to maintain the current soil nutrient levels. For S, it turns out that maintenance inputs are also sufficient to completely eliminate any soil S deficiency and thus the distinction of capital and maintenance does not apply.
3) Mining (Nil) soil nutrient levels will have little effect on pasture production if the initial nutrient levels are within or above the optimal range.

Nutrient Requirements

To achieve these strategies, the estimated nutrient inputs are:

Nutrient Inputs (kg/ha/yr)				
Block	**P**	**K**	**S[1]**	**Mg**
Flats	25	150 (120 capital, 30 maintenance)	50	0
Downs	75 (50 capital, 25 maintenance)	150 (120 capital, 30 maintenance)	50	0
Hill	12	0	50	0

Notes: 1) Amount of soluble S to be available over the following 12 months.

These are the recommended nutrient inputs for the next 12 months.

It is estimated that the capital inputs of P recommended for the Downs block will increase the Olsen P levels by 10 units putting it into the appropriate optimal range. The capital inputs of K for the for the Flats and Downs blocks should increase the soil K level by 1-2 units, and there may be a requirement for additional capital inputs next year to raise soil K levels into the optimal range. For this soil group, the inputs of S recommended above should be sufficient to eliminate even the most extreme S deficiency but the organic S test will only increase very slowly (and on some drier soils not at all) over time.

Further soil testing is recommended in July 2019 and the nutrient inputs will be amended accordingly. The goal is to get all the soil nutrient levels into their respective optimal ranges, and maintain them there, with a maintenance fertiliser program.

Least Cost Fertiliser

The least-cost fertilisers that best match the recommended nutrient inputs are as follows:

Block	Fertiliser	Application Rate (kg/ha)[1]	Cost ($/ha)[2]
Flats	Superten 25K	600	$272
Downs	Special Mix (74% Superten, 26% Muriate of Potash)	1130	$429
Hill	Sulphur gain 30S	170	$61

Notes: 1) The application rates given above are the total annual inputs.
2) Ex works (based on current Ballance fertiliser prices as at 13 July 2018).

The total cost of this program is approximately $290,000 ex works. While there should be no doubt that eliminating nutrient deficiencies is always economic in the long-term (5-10yrs), the above recommendation greatly exceeds the fertiliser budget. Accordingly, the capital fertiliser will need to go on over time and the following fertiliser mix is recommended for the next 12 months:

Block	Fertiliser	Application Rate (kg/ha)[1]	Cost ($/ha)[2]
Flats & Downs	30% Potash Sulphur Super (15K)	430	$181

Notes: 1) The application rates given above are the total annual inputs.
2) Ex works (based on current Ballance fertiliser prices as at 13 July 2018).

Note that this input of fertiliser will apply 25, 65 and 60 kg/ha of P, K and S. This represents maintenance inputs of P and S and a small capital input of K (45 kg K/ha). Further capital inputs will be required to optimize pasture production.

Nitrogen Fertiliser

Background

In our clover-based pastoral system there are two ways of getting nitrogen (N) into the soil: via conversion of the atmospheric N to protein N in clover, or applied as fertiliser N. The former is far cheaper than the latter by about 5 times and therefore the priority in any efficient pastoral operation is to maximise clover growth. Not only is clover N a cheaper source of N but it is an inherently better quality animal feed.

Correcting the nutrient deficiencies identified on this farm (P, K and S) will improve clover growth and with it, the input of clover N into the soil. This biological process takes time however (6-24 months) and should reduce the need for fertiliser N in the future. In the meantime, some fertiliser N may be required to meet possible feed shortfalls.

Fertiliser N is recommended as follows:

Block	Nitrogen Type	Application Rate (kg/ha)[1]	Cost ($/ha)[2]
Flats	Urea	110	$53

Notes: 1) The application rates given above are the total annual inputs. Note that the fertiliser N recommendation is only a guide. The actual amounts of fertiliser N used in any given season will depend on the climate and likely feed shortfalls.
2) Ex works (based on current Ballance fertiliser prices as at 13 July 2018).

[Note: Urea is still the cheapest form of fertiliser N. Also, because it doesn't contain other nutrients (i.e. is not a compound fertiliser) its use allows for greater flexibility in terms of the timing, the rate and the area to be treated. For maximum efficiency, both agronomic and financial, it is recommended that the annual inputs given above are applied at between 20-30 kg N/ha (45-65 kg urea/ha) per application, with applications being made 4 to 6 weeks prior to likely feed shortfalls].

Lime Requirements

Background
For ground-spread applications of lime on dairy farms, it is always economic to lime soils to the biological optimum soil pH (5.8-6.0). However, for soils with a pH > 5.5 the size of the pasture responses to liming are about 1-5%. In contrast, correcting nutrient deficiencies can result in increases in pasture production of 10-20-30% depending on the severity of the deficiency. Thus, if the fertiliser budget is constrained the priority is to correct any nutrient deficiencies first, and once this is achieved, develop a liming program.

The Downs block is currently below the economic optimal pH range of 5.8-6.0. Assuming that there are **no budget constraints** (fertiliser should take priority), lime, is therefore recommended as follows (As a rule of thumb 1 tonne/ha lime will increase the soil pH by 0.1 pH units):

Block	Application Rate (t/ha)	Cost ($/ha)[1]
Downs	3	$150

Note: 1) On basis of $27.00/tonne Lime, transport and application cost of $23/tonne.

[Note: Legume-based pastures slowly acidify the soil and hence the soil pH needs to be regularly monitored with annual soil testing and a liming program will be commenced when needed].

Important, please note:

1. **Liming can increase soil Mo availability and hence increases pasture Mo concentrations. Excessive Mo intake can induce Cu deficiency. If the pasture Mo levels are already elevated (i.e. > 1 ppm) or there is an ongoing history of Cu deficiency, caution is necessary and pasture Mo and animal Cu levels should be assessed prior to liming.]**

Hay, Silage and Baleage Paddocks

Background
Each tonne of pasture dry matter (DM)/ha removes about 40 kg N and K/ha and 3 kg P and S/ha. Thus, they are very demanding on soil N and K reserves. Typical hay/silage crops yield between 2-3 tonnes DM/ha. As a rule of thumb, a pasture at 15-30 cm height is about 2 tonnes DM/ha. A heavier crop (3 tonnes/ha) is likely to be about 25-30 cm.

On this farm it is necessary to use the same paddocks each year and the supplements are then distributed all over the farm. Thus, additional fertiliser is required, over and above the normal maintenance, to make good the nutrient losses. Assuming a silage/hay crop of 2.5 tonne DM/ha is taken off, it is recommended that after the crop is removed apply 300 kg/ha Special Mix (67% Muriate of Potash & 33% Superten). If fertiliser N is also required then at shut-up apply 360 kg/ha Special Mix (55% Muriate of Potash, 24% Superten & 21% Coated Urea).

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Cropping

Crops are grown routinely on this farm to provide additional winter feed.

Soil fertility

Much of the Downs block is scheduled to go into crop for the 2018/19 season. The soil fertility for the block is summarised below together with the optimal range required for the crop.

Paddocks	pH	Olsen P	K	Sulphate S	Mg	Na
Downs	5.5	9	4	5	23	6
***Optimal*[1]**	*5.8-6.0*	*20-25*	*5-7*	*>5*	*8-10*	*?*

Note: 1) Based on a soil core depth of 150 mm taken prior to cultivation.

The 'rule of thumb' is to bring all the nutrient levels up to the optimal range prior to planting and then add some N and P 'down the spout', or top-dressed with the seed, at the time of sowing (this assists with plant establishment). Additional fertiliser N may be applied depending on the soil N status (This is determined largely by the number of years since the paddock was in pasture).

The results above indicate that pH, P and K are below the optimal range, therefore in addition to replacing the nutrients removed by the crop, some P and K is required to raise the soil P and K status.

[Caution: Excess S in brassica crops can give rise to 'red-water' in cows]

Fertiliser recommendation

Taking into account these soil nutrient levels, and adopting a no-risk fertiliser strategy, the following fertilisers are recommended:

Timing	Fertiliser	Nutrient inputs (kg/ha)				
		N[1]	P	K	S	Mg
Pre-plant	3 tonnes lime Special Mix 940 kg/ha (64% Superten, 32% Muriate of potash, 4% Urea) plus 12 kg Granular Boron /ha	17	55	150	63	0
Plant	DAP (100 kg/ha)	18	20	0	0	0
Post-emergence	250 kg Urea / ha	115	0	0	0	0
Total		150	75	150	63	0

Notes: 1) Brassica crop response to N varies depending on soil N levels and the growing season. The advantage of split N applications is that the amount applied as a topdress can be adjusted based on crop progress.

Ongoing Monitoring

Ongoing monitoring is essential, especially when either mining soil nutrient levels down or applying capital inputs. Further soil tests should be taken from the same transects in July 2019.

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1 August 2018