The Northland Dairy Development Trust
&
The Northland Agricultural Research Farm

‘Making Up For Lost Ground’

Field Day – 24th June 2020

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NDDT Science Manager:	Chris Boom, AgFirst Northland
NDDT Coordinator:	Kim Robinson, AgFirst Northland

PROGRAMME

10:30 - Welcome

10:40 – Managing Low Cow Condition – Jane Kay

11:10 – N, S, K Response Trial

11:25 – NARF Trial 2019/20 Results – Kim Robinson

Noon – Farm Walk

1:20 – Lunch

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Acknowledgements

Thanks to the funders and sponsors who have made this project possible. Special thanks to the NDDT trustees and NARF committee members who have give their time and energy to make this project happen.

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Dairying in a Variable Climate Project – NARF

Chris Boom and Kim Robinson (NDDT, AgFirst Northland)

This trial is being run by the Northland Dairy Development Trust (NDDT) in conjunction with the Northland Agricultural Research Farm (NARF). The project is funded by DairyNZ, Ministry of Primary Industries (Sustainable Farming Fund) and Hine Rangi Trust with support from commercial sponsors.

Summary

This is a 3 year farm systems trial investigating the use of palm kernel extract (PKE) and other supplements on farm production and profitability. There are three independent 28ha farmlets :

- **Pasture Only farm**, (2.7 cows/ha) no imported feed
- **PKE Only farm**, (3.1 cows/ha) imports PKE to fill pasture deficits
- **PKE Plus Farm**, (3.1 cows/ha) imports PKE and other supplements to fill pasture deficits.

PKE is fed on the PKE Only and PKE Plus farms only when grazing residuals indicate pasture supply is limiting. Other supplements (DDG and baled silage) are fed on the PKE Plus farm when milk FEI levels indicate no further PKE can be fed without incurring penalties.

Key features of 2019/20 season

- wet Aug/Sept which led to severe feed shortage on Pasture Only Farm and 8% cows culled Sept
- prolonged drought leading to FEI pressure on PKE Only Farm and 55% cows dried off in March

These difficult climatic conditions resulted in lower milk production and lower pasture eaten compared to the previous season.

	Kg MS/ha		Pasture Eaten tDM/ha	
	2018/19	2019/20	2018/19	2019/20
Pasture Only Farm	996	816	12.6	10.9
PKE Only Farm	1,225	1,129	13.2	11.6
PKE Plus Farm	1,300	1,279	12.6	11.4

This also led to higher supplements being imported. Despite this the response rates to supplement were similar to the previous season at around 100gMS/kgDM fed.

	Imported Supplement kgDM/cow		Response kgMS/kgDM fed	
	2018/19	2019/20	2018/19	2019/20
Pasture Only Farm	0	0		
PKE Only Farm	748	978	100	102
PKE Plus Farm	1,046	1,410	94	104

Financial analysis of the farms considers labour and other variable costs. With a milk price of $6.35/kg MS during the 2018/19 season, farm operating profit (EBIT) was highest on the PKE Only Farm. Despite a higher predicted milk price during 2019/20 ($7.20/kg MS), profit on all farms was significantly lower than the previous season. This was due to the drought reducing milk production and increasing the supplement usage (on the supplemented farmlets). The PKE Plus farm was the most profitable due to hitting the sweet spot of

a high milk price with unfavourable weather, showing the high cost of having to dry cows off early on the other farms.

Operating Profit	Milk Price $6.35/kgMS	Milk Price $7.20/kgMS	Diff between years
$/ha	2018/19	2019/20	
Pasture Only Farm	$3,064	$1,926	- $1,138
PKE Only Farm	$3,365	$2,187	- $1,178
PKE Plus Farm	$3,055	$2,413	- $642

Marginal Milk Cost

This trial provides the opportunity to calculate the marginal cost of the extra milk produced on the supplemented farms compared with the Pasture Only farm. This shows the additional milk costing $6.54/kg MS on the PKE Only farm and $6.27/kg MS on the PKE Plus farm. Further analysis shows for each dollar spent on purchasing PKE on the PKE Only farm, $0.85 was added to other farm expenses.

Sensitivity

The 2019/20 financial results show that at a $7.20/kg MS milk price, there was an advantage to putting PKE and other supplements into the farm system. However the Pasture Only farm was the most profitable at a $6.00 milk price indicating that the PKE farms needed the high milk price to pay for their supplements.

Operating Profit	Milk Price	Milk Price
$/ha	$6.00	$7.20
Pasture Only Farm	$947	$1,926
PKE Only Farm	$832	$2,187
PKE Plus Farm	$878	$2,413

The operating profit per ha is somewhat sensitive to PKE price (figures are at $7.20/kgMS milk price).

	Pasture Only	PKE Only	PKE Plus
Operating Profit at $200/t PKE	$1,926	$2,611	$2,879
Operating Profit at $300/t PKE	$1,926	$2,269	$2,497
Operating Profit at $400/t PKE	$1,926	$1,928	$2,115

The operating profit per ha is more sensitive to the milk response from feeding supplements. The figures below are calculated on the PKE Only farm. A poor milk response can strip profits very quickly. Poor responses arise from supplement wastage and poor pasture management, particularly when grazing residuals are not monitored well. Simple decision rules should be adhered to for maximum responses.

Response to Supp	$6.00/kgMS	$7.20/kgMS
102gMS/kgDM fed	$832	$2,187
80gMS/kgDM fed	$426	$1,701
60gMS/kgDM fed	$57	$1,257

This project has illustrated that although imported supplements can have a role in improving farm production and profit, care needs to be taken that costs are closely monitored and milk responses are maximised through careful pasture management.

Background

This project is a farm systems experiment that compares three different management strategies within a variable climate and the constraints of milk fat evaluation index (FEI). The project is being conducted at the Northland Agricultural Research Farm (NARF), commenced in June 2018 and runs for three years.

Data collected allows examination of the effects of these systems on milk production, farm operating profit, environmental sustainability, cow welfare, labour, and capital requirements. This project will assist farmers in developing more resilient, profitable, and potentially lower impact farming systems.

Farmlet structure

All farms are self-contained farm systems. Each farm is 28 ha with paddocks allocated so pasture growth potential is similar across farms. Silage can be made when there is a pasture surplus and fed when pasture supply below feed demand.

The three farm systems are:

1. ***Pasture Only – 2.7 cows/ha***

   A simple pasture only system. Silage is made when pasture surpluses occur and fed back as required.

2. ***PKE Only – 3.1 cows/ha***

   PKE is fed when pasture grazing residuals fall below target levels while maintaining ideal grazing rotation length. PKE is not used to create a pasture surplus for conservation. PKE use is constrained by the need to keep the milk fat evaluation index (FEI) within the acceptable limits set by Fonterra.

3. ***PKE Plus – 3.1 cows/ha***

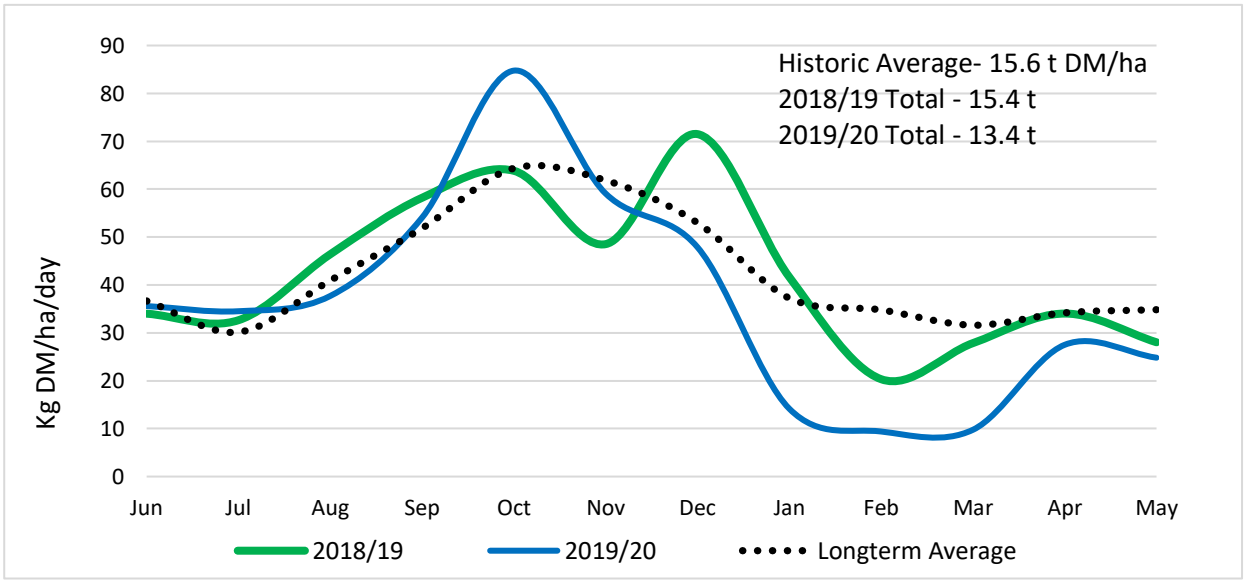
   Supplements are fed when pasture grazing residuals fall below target levels. PKE is used first until milk FEI limits are reached and then alternative spot market feed sources are used.

Full Results

Pasture Growth

Pasture growth during the 2018/19 and 2019/20 seasons are shown in the graph below as calculated by post and pre-grazing pasture assessments. The 2019/20 season has been marked by a prolonged drought. Total pasture production during 2019/20 season was 2t DM/ha lower than average. Around 150kgN/ha was used on all three farmlets.

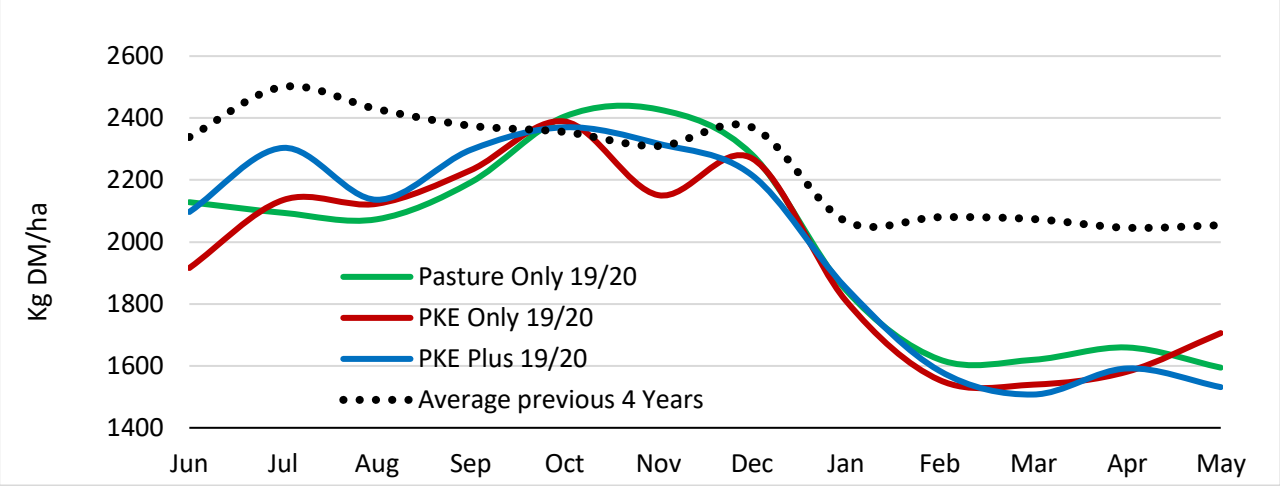
Figure 1. Calculated pasture growth rates at NARF (average of three farmlets)



Pasture Covers

Throughout much of the 2019/20 season, farm pasture cover was lower than the average of the previous four seasons (see Figure 2) with the drought keeping pasture covers around 1600 kg DM/ha from February through to May. For most of the season there was little difference between farms.

Figure 2. Average farm pasture cover for the 2019/20 season compared with the average of the previous four seasons.



Supplement Use

Table 1 shows the supplement fed during the 2019/20 season along with area cut for silage. Good pasture growth conditions allowed all farms to make baleage through late spring, though the Pasture Only farm made twice the amount of the other two farms (due to lower stocking rate). This baleage was very valuable and was mainly fed back onto the farms during summer/autumn.

The PKE feeding level was constrained by milk FEI through much of summer and autumn. During this period, feeding was generally around 3 kg DM PKE/cow/day with slightly more for the PKE Plus herd which was getting other supplements through much of this time. The costs below include delivery charges which were $23/t for PKE into the bin and $60/t for DDG into the silo.

Table 1. Supplements fed during 2019/20 season (kg DM/cow), price of supplements landed (¢/kg DM) and % of farm cut for silage.

	Supplement	Kg DM/cow	Cost of Supplement Delivered	Cost of Supplement ¢/kg DM	% of Farm Cut for Silage
Pasture Only Farm	Grass Silage (home-made)	**404**	$44/b	14.4	57%
PKE Only Farm	Grass Silage (home-made) PKE **Total**	181 978 **1159**	$44/b $324/t	14.4 35.4	28%
PKE Plus Farm	Grass Silage (home-made) PKE DDG Grass Silage (purchased) **Total**	156 1,093 210 107 **1,567**	$44/b $324/t $624/t $90/b	14.4 35.4 69.4 35.0	25%

Stocking Rate Management and Milking Frequency

The farms are governed by decision rules to ensure animal welfare is maintained. If cow condition is low (3.5 or less) and feed is not available then cows are put on once-a-day milking (OAD), dried off or culled to reduce feed demand.

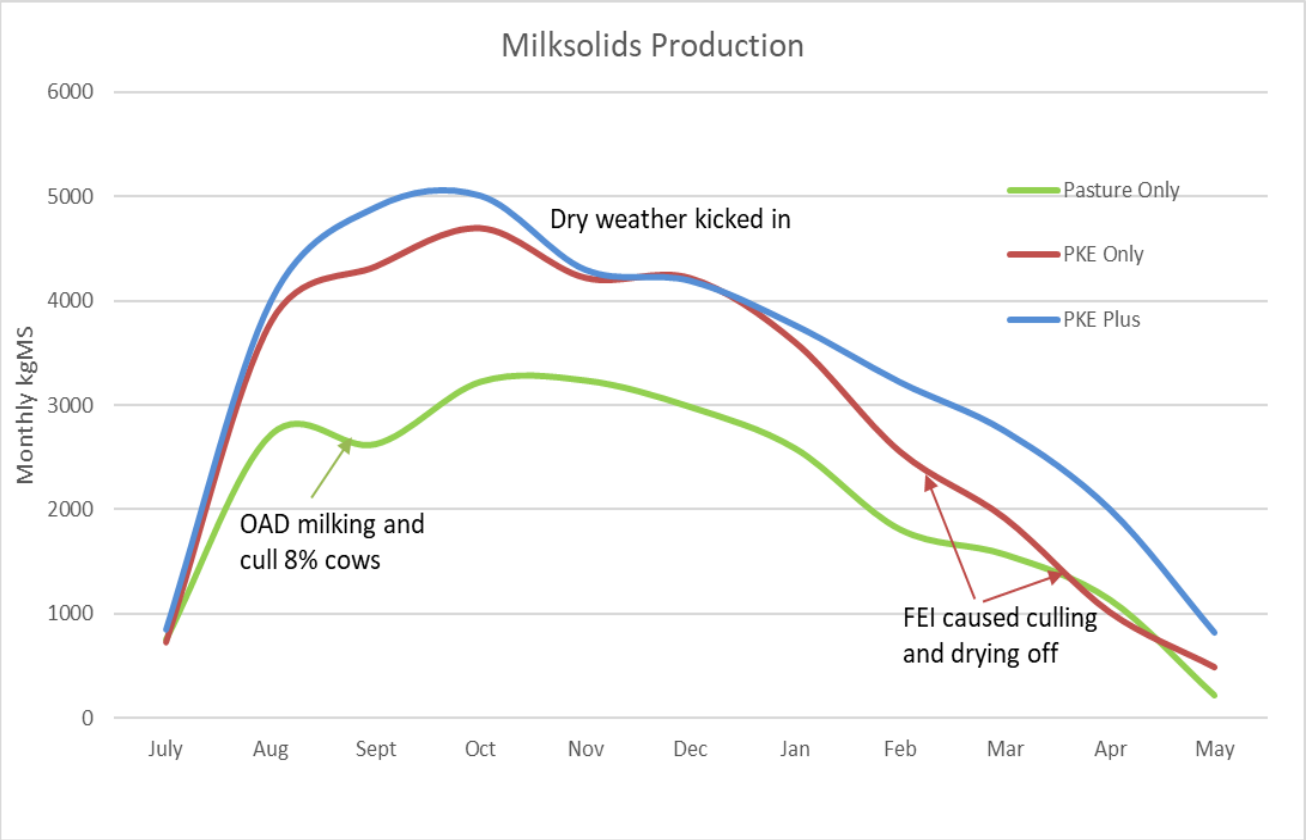
During spring 2019 all cows on the Pasture Only farm were placed on OAD milking for 4 weeks due to low pasture cover and falling cow condition. In comparison only a handful of cows from the PKE Only and PKE Plus farms were placed on OAD.

Low pasture cover and poor pasture utilisation continued on the Pasture Only farm resulting in the need to reduce stocking rate by culling 8% of the herd on 12 September. Empty cows were taken out in late February and then light cows were dried off in late March. Of cows calved, 64% were milked through to early May when all were dried off.

The PKE Only farm encountered high milk FEI in late February so culls were removed. An additional 40% of the herd was dried off in late March due to elevated milk FEI. Only 42% of cows remained milking through to 20th May.

PKE Plus cows had culls taken out in early March and had 78% of calved cows milked through to 20th May.

Figure 3. Monthly milksolids production for the 2019/20 season



Milk Production and Mating

Milk production during 2019/20 was significantly lower than the 2019/20 season for the Pasture Only and PKE Only farms, mainly due to drought and earlier culling and drying-off. The PKE Plus farm dropped slightly compared to the previous season. Despite the difficult spring there was no difference in mating results.

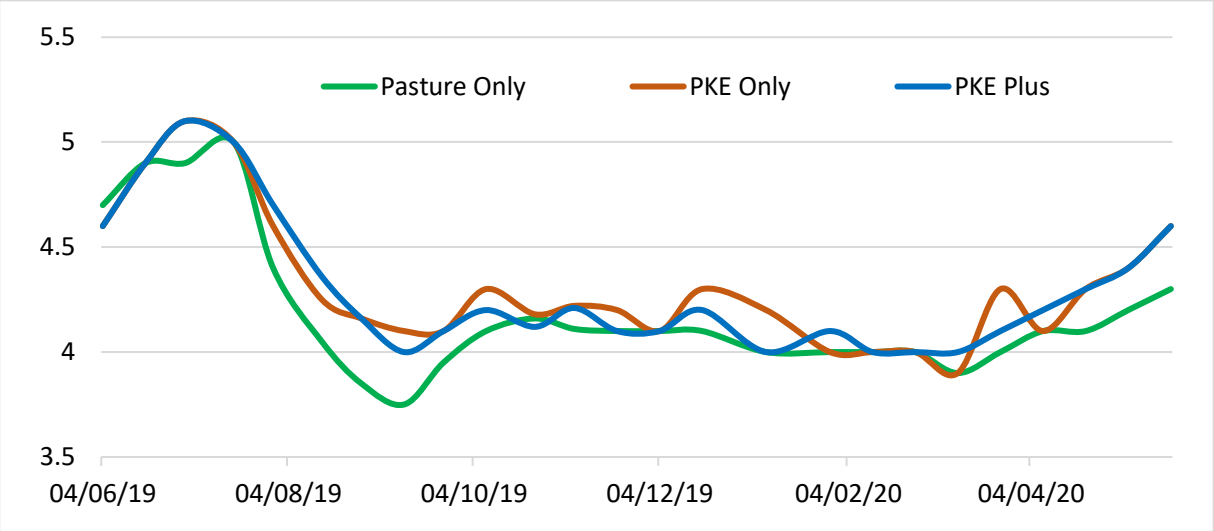
Table 2. Total milk solids production per ha and per cow and empty rate (cows in calf/cows at mating).

	Kg MS/ha		Kg MS/Cow		Empty Rate	
	2018/19	2018/19	2018/19	2019/20	2018/19	2019/20
Pasture Only Farm	996	816	372	313	9%	6%
PKE Only Farm	1,225	1,129	403	359	11%	6%
PKE Plus Farm	1,300	1,279	423	407	6%	7%

Body Condition Score

Body condition score (BSC) is assessed fortnightly. The Pasture Only farm had lower condition score during spring and late autumn than the other farms. Earlier drying-off allowed the Pasture Only cows to regain condition faster during May.

Figure 4. Average herd body condition score - 2019/20 season.



Responses to PKE

Comparing milk production on the two PKE supplemented farms with the Pasture Only farm provides a calculation of milk solids (MS) response to supplement on a whole farm system basis. These supplement response rates are lower than the three previous seasons which averaged 122 g MS/kg DM PKE fed. Overall, response rates on the PKE Plus farm were similar to the PKE Only farm, despite the use of DDG which has higher energy and protein levels than PKE.

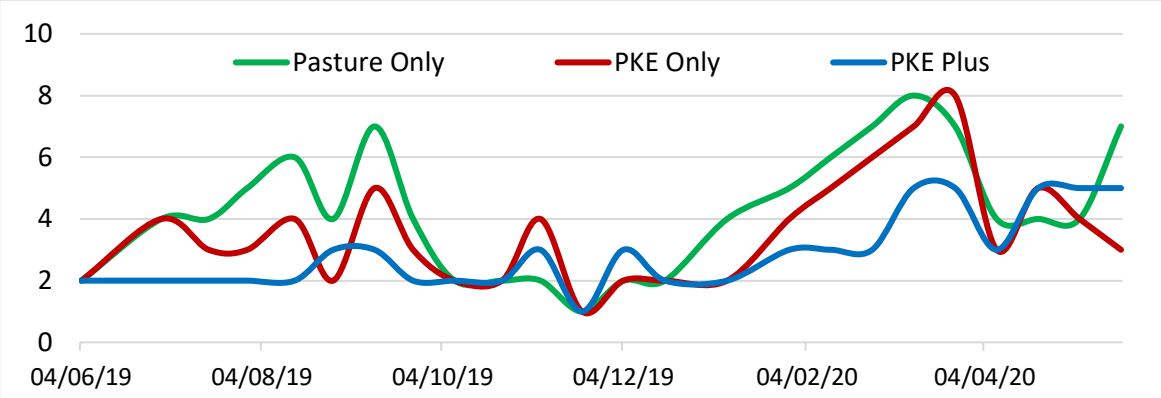
Table 3. Supplement response calculations relative to the Pasture Only farm (g milk solids/kg DM supplement fed).

	PKE Only farm		PKE Plus farm	
	2018/19	2019/20	2018/19	2019/20
Milk Solids Response g/kg DM supplement fed	**100**	**102**	**94**	**104**

Worry Score

A worry score has been assessed fortnightly. This relates to the concern the manager has about cows and feed supply. The Pasture Only farm had a higher worry score during late winter/spring and summer, largely due to the inability to bring in additional feed. The worry score for the PKE Only farm was also elevated during late summer/early autumn when milk FEI was constraining PKE feeding.

Figure 5. Managers worry score for the three farms (1 = low, 10 = high).



Pasture Eaten

The table below shows the pasture eaten calculation for the 2018/19 and 2019/20 seasons. The effect of the drought can be clearly seen in the large drop in Pasture Eaten across all farms.

Table 4. Calculated pasture eaten (t DM/ha/year)

	2018/19	2019/20
Pasture Only farm	12.6	10.9
PKE Only farm	13.2	11.6
PKE Plus farm	12.6	11.4

Differences in Labour & Machinery

Time spent doing tasks on each individual farm has been calculated, over and above farm operations that are common to all farms. The table below shows the additional time required by NARF staff for feeding out and moving cows to and from the feed pad. These results have been used to adjust the allocation of labour and vehicle expenses within the financial analysis.

Table 5. Additional labour and tractor time for each farm for feeding supplements in the 2019/20 season.

	Additional Tractor Hours	Additional Labour Hours
Pasture Only farm	45	45
PKE Only farm	95	337
PKE Plus farm	123	383

Financial Analysis

The financial results for the three farms have been calculated and are shown in Table 6. A milk price of $7.20/kg MS has been used for milk income. Expenses are based on actual expenses with some adjustments for labour and administration to compensate for extraordinary expenses involved in running the research farm. Records of additional labour and tractor time for each farm have been used to adjust the vehicle, R&M and depreciation expenses.

For the 2019/20 season, farm working expenses/kg MS were lowest on the Pasture Only farm and highest on the PKE Plus farm. Farm operating profit was highest on the PKE Plus farm, followed by the PKE Only farm. At a milk price of $6.00/kg MS the Pasture Only Farm would have been slightly more profitable. This is because there were significant cost savings during the OAD milking periods. During the previous season farm operating profit was highest on the PKE Only farm, while being similar on the other two farms with a milk price of $6.35/kg MS.

Feeding supplements increases farm costs other than just the cost of the supplement itself. On the PKE Only farm, each dollar spent on purchasing PKE had an additional $0.85 of other farm expenses. For the PKE Plus farm this was $0.61 on top of each dollar spent on purchasing supplement.

The 2019/20 financial results show that at a $7.20/kg MS milk price, there was an advantage to putting PKE into the farm system. This was further enhanced when additional supplements were added even though these supplements were at a significantly higher price. This economic return from high priced supplements was largely related to the ability to continue milking most cows through to May.

The cost of the additional milk produced by the supplemented farms can be calculated can be compared to the Pasture Only farm. This cost was $6.54/kgMS for the PKE Only farm and $6.27/kgMS PKE Plus farm. This compares to the previous season where the cost of the marginal milk was $5.39 and $6.67 for the PKE Only and PKE Plus farms.

Table 6. 2019/20 season income, expenses and operating profit for the three NARF farms.

Financial Summary 2019/20	Pasture Only Farm	PKE Only Farm	PKE Plus Farm
Income	**$/ha**	**$/ha**	**$/ha**
Income from milk ($7.20/kg MS)	$5,875	$8,129	$9,212
Dividends	$30	$30	$30
Income from stock sales	$267	$322	$322
Total Income	**$6,172**	**$8,479**	**$9,564**
Expenses			
Wages	$1,082	$1,648	$1,699
Animal Health	$173	$205	$205
Breeding Expenses	$177	$211	$211
Shed expenses	$107	$123	$123
Electricity	$159	$186	$186
Grazing	$442	$533	$533
Calf rearing	$36	$43	$43
Silage Making	$177	$84	$79
PKE		$1,107	$1,230
DDG			$458
Purchased Silage			$116
Nitrogen/Fert	$369	$396	$396
Regrassing	$121	$121	$121
Weed and Pest	$134	$134	$134
Vehicle Expenses	$158	$227	$267
R&M General	$409	$440	$440
R&M Effluent	$27	$42	$42
Administration	$128	$133	$133
Rates and Insurance	$219	$227	$227
Depreciation	$303	$435	$511
Total Operating Expenses	**$4,246**	**$6,294**	**$7,151**

Farm Working Expenses/kg MS	**$4.83**	**$5.10**	**$5.19**
Operating Profit			
Operating Profit at $7.20/kg MS	**$1,926**	**$2,187**	**$2,413**
Cost of Marginal Milk		**$6.54**	**$6.27**
Alternative Milk Prices			
Operating Profit at $4.00/kg MS	**-$685**	**-$1,426**	**-$1,681**
Operating Profit at $6.00/kg MS	**$947**	**$832**	**$878**
Operating Profit at $8.00/kg MS	**$2,579**	**$3,090**	**$3,436**
Alternative PKE Prices (delivered wet weight)			
Operating Profit at $200/t PKE	**$1,926**	**$2,611**	**$2,879**
Operating Profit at $300/t PKE	**$1,926**	**$2,269**	**$2,497**
Operating Profit at $400/t PKE	**$1,926**	**$1,928**	**$2,115**

The profitability was somewhat sensitive to change in PKE price this season as shown above. This is because significantly more PKE was fed in response to the drought. (3-3.5tDM/ha compared to 2.3tDM/ha last season)

The profit was also sensitive to the milk response to supplements. A relatively small change in milk response can drop profit by $500/ha. Good milk responses are driven primarily by minimizing supplement wastage during feeding and efficient pasture management through monitoring of grazing residuals. Both PKE farms follow strict decision rules on feeding supplement only when grazing residuals are below target levels. PKE feeding is adjusted at least every two weeks. Supplements are not fed to support daily production levels.

Table 7. Operating Profit at different milk response rates to PKE (on the PKE Only farm)

Response to supp	$6.00/kgMS	$7.20/kgMS
102gMS/kgDM fed	$832	$2,187
80gMS/kgDM fed	$426	$1,701
60gMS/kgDM fed	$57	$1,257

Poor milk responses can quickly strip profits and farmers should focus as much on efficient supplement use through monitoring residuals as minimizing supplement price.

Acknowledgements

Thanks to NARF staff for making this project happen, especially Kelvin Horton and Johan Van den Berg. Special thanks to NDDT trustees and NARF committee members for their support and commitment in proposing and overseeing this project.

Pasture Growth Response in Northland to Nitrogen, Sulphur and Potassium

Chris Boom – NDDT Science Manager

Summary

This study was driven by farmers asking whether it was economic to apply Ammo or Potash instead of straight urea in spring. It looked at pasture growth responses to adding sulphur and potassium to nitrogen applications during late winter and early spring across three soil types in Northland.

Pasture growth responses to nitrogen were very high on the Okaihau Gravelly Loam (39:1 - kg DM/kg N), moderately high on the Wharekohe Silt Loam (21:1) and lower on the Kaipara Clay (10:1).

The addition of sulphur showed a good response on the Wharekohe soil (average of 11:1 – kg DM/kg S), while the other soils showed poor responses (average 3:1). These responses appeared to be in line with soil test deficiencies. Applying sulphur in August versus September or at both times did not significantly change the response to sulphur.

Responses to potassium were also variable across soil types with a reasonable response on the Kaipara Clay (9:1 kg DM/kg K) and poor responses on the other soil types. It is noted that potassium likely provided a longer lasting effect than measured in this study.

Within this study, nitrogen applications were the cheapest means of boosting pasture growth during late winter/early spring. The addition of sulphur and potassium appeared to be site specific. This study would indicate that increasing application rates of nitrogen may be a more cost effective means of improving pasture production compared to adding other nutrients. However, low rainfall during autumn and winter, prior to the commencement of the project, likely reduced leaching of sulphur and potassium compared to a more normal season.

Background

Most Northland dairy farmers apply nitrogen to their pastures during winter and spring to increase pasture production. Many will also include sulphur and/or potassium to ensure these elements are not limiting. This is commonly applied as products such as Sustain Ammo or PhaSedN Quick Start for sulphur or SustaiN 20K for potassium. Some are convinced of the benefits of using these multi element products whilst others are convinced that nitrogen alone gives the best economic response.

Very little published research exists for Northland to determine responses to sulphur or potassium with nitrogen during winter and early spring. Rogers and Putt (1997), showed a good response to the addition of sulphur on a Wharekohe silt loam soil but no response on a Kaipara clay. This was only investigated with one application time and with minimal monitoring.

Research from other regions has less relevance due to Northland's warmer temperatures and high incidence of poorly drained soils with low anion storage capacity, not common where the majority of research has been undertaken. Farmers may be adding these elements unnecessarily, or may be missing out because they are not including these elements.

This trial was designed to test the responses to nutrients farmers commonly apply during late winter and early spring on a range of soil types in Northland.

Trial Design and Methods

A trial was conducted on three sites/soil types, being a Kaipara Marine Clay, a Wharekohe Silt Loam and an Okaihau Gravelly Loam. Table 1 shows the treatments applied.

Table 1. Treatments applied to plots in early August and mid-September.

Treatment Name	Early August Application	Mid-September Application
Control	Nothing	Nothing
N only (twice)	30 kg N/ha as Sustain	30 kg N/ha as Sustain
N + S 1st Appl	Ammo 30N (30 kg N/ha)	30 kg N/ha as Sustain
N + S 2nd Appl	30 kg N/ha as Sustain	Ammo 30N (30 kg N/ha)
N + S Both Appl	Ammo 30N (30 kg N/ha)	Ammo 30N (30 kg N/ha)
N + K	30 kg N/ha as Sustain	30 kg N/ha as Sustain + 22 kg K/ha as MOP
N + S 2nd Appl + K	30 kg N/ha as Sustain	Ammo 30N (30 kg N/ha) + 22 kg K/ha as MOP
N + S Both Appl + K	Ammo 30N (30 kg N/ha)	Ammo 30N (30 kg N/ha) + 22 kg K/ha as MOP

Treatments at each site were replicated 5 times ginving 40 plots/site. Plots were 2m x 4m on ryegrass dominant pastures. Plots were mown twice prior to the first treatment being applied.

Average date (across three sites) of the first treatment application was 11th August and the second application 16th September. Pasture growth was monitored for four growth periods following the first treatment application as shown in table 2. At the end of each growth period plots were mown and the harvested material weighed wet with a subsample taken for DM analysis to calculate pasture DM responses.

Table 2. Average (across the three sites) harvest date and length of growth period prior to harvest.

	1st Harvest	2nd Harvest	3rd Harvest	4th Harvest
Harvest date	16th Sep	15th Oct	13th Nov	14th Dec
Duration of growth period (days)	36	29	29	31

Sites were soil sampled to a depth of 75mm for nutrient analysis at the time of both treatment applications. Soil test results are shown in table 3.

Table 3. Average of two soil tests taken at each site and nutrient applications in the six months prior to the start of the trial (MAF Quick Test – Hill Laboratories).

	Soil Test Results				**Nutrients Applied (kg/ha) in the six months prior to the study**		
	pH	Olsen P	Sulphate Sulphur	Potassium	Nitrogen	Sulphur	Potassium
Kaipara Marine Clay	6.2	62	7	18	37	0	0
Wharekohe Silt Loam	6.6	38	4	5	30	0	25
Okaihau Gravelly Loam	6.0	30	23	7	120	68	45
Medium Range	5.8-6.2	20-30	10-12	7-10			

A clover presence survey was undertaken prior to the final harvest on the Kaipara Clay and Wharekohe Silt Loam sites.

Results

Rainfall in the autumn and early winter period was significantly lower than average on all sites (prior to the commencement of the trial). Late winter and spring rainfall was near average.

Table 4 shows the herbage harvested over the four growth periods. This data was used to calculate the main effects shown in later tables.

Table 4. Herbage harvested (kg DM/ha), sum of all four harvests.

Kg DM/ha	Kaipara Clay (Dargaville)	Wharekohe Silt Loam (Maungatapere)	Okaihau Gravelly Loam (Okaihau)	**Average of all sites**
Control	6100	4310	3229	**4546**
N only (twice)	6698	5565	5583	**5949**
N + S 1st Appl	6558	5706	5422	**5895**
N + S 2nd Appl	6897	5781	5819	**6166**
N + S Both Appl	6844	5790	5684	**6106**
N + K	6916	5334	5581	**5943**
N + S 2nd Appl + K	7192	5949	5755	**6299**
N + S Both Appl + K	7005	5926	5813	**6248**

Table 5 shows the main treatment effects for the three sites (soil types). The two single sulphur application treatment responses have been amalgamated to simplify this data, as have been the three potassium treatment responses.

Response to nitrogen was greatest on the Okaihau Gravelly Loam. This total response is very high compared with published nitrogen responses. The nitrogen response on the Wharekohe soil was also high, whereas the Kaipara Clay showed a more typical response (10 kg DM/kg nitrogen applied). All of the nitrogen response occurred within 5 weeks of nutrient application.

Response to sulphur was lower than the response to nitrogen on all sites. Response to sulphur applications appeared to be greatest on the Wharekohe Silt Loam with little response on the other two soil types. Applications of sulphur were high in the six months prior to the trial on the Okaihau soil, showing as high sulphate sulphur levels in the soil tests, likely leading to the low sulphur response.

As with nitrogen, response to sulphur appeared to have a short-term effect with all the response showing within 5 weeks of application. It is likely that sulphur responses shown in this study were lower than would normally be expected due to low autumn and winter rainfall resulting in little leaching of sulphur prior to treatments being applied.

Potassium responses overall were also lower than nitrogen responses. The response to potassium was greatest on the Kaipara Clay, with little response on the other two sites. This is surprising given the potassium levels in the soil tests were high on the Kaipara Clay soil. The clover presence survey during early summer showed no effect as a result of potassium application.

As might be expected, response to potassium appeared to have a slower and longer lasting effect, with most of the response showing in the last two harvests. This study monitored pasture growth for 89 days after nutrient application. It is acknowledged that the effect of potassium would largely show as improved clover presence, which may have continued to show after monitoring stopped.

Table 5. Main treatment effects – total response to nutrient applied (kg DM/kg nutrient applied) for the three trial sites (soil types).

Kg DM/kg Nutrient Applied	Kaipara Clay	Wharekohe Silt Loam	Okaihau Gravelly Loam	**Average All Soil Types**
Nitrogen	10.0	20.9	39.2	**23.5**
Single Application of Sulphur	2.1	13.0	2.7	**6.0**
Double Application of Sulphur	5.3	8.2	3.7	**5.7**
Potassium	9.4	1.1	1.0	**4.1**

Table 6 shows the cost of nutrient based on pricing at September 2019 (including the cost of cartage and application at $160/tonne). The cost of additional pasture growth is then calculated based on the treatment responses. There were large differences in calculated cost of additional pasture growth between soil types driven by differences in responses. Averaging over all soil types shows nitrogen having approximately three times the cost effectiveness of sulphur or potassium.

Table 6. Cost of nutrient (applied) and calculated cost of additional pasture grown/kg DM.

		$/kg additional DM		
Kg DM/kg Nutrient Applied	$/kg Nutrient	Kaipara Clay	Wharekohe Silt Loam	Okaihau Gravelly Loam
Nitrogen	$1.85	$0.19	$0.09	$0.05
Single Application of Sulphur	$1.48	$0.69	$0.11	$0.54
Double Application of Sulphur	$1.48	$0.28	$0.18	$0.40
Potassium	$1.77	$0.19	$1.60	$1.86

Conclusions

This study was instigated to investigate the response to adding sulphur and potassium to nitrogen applications across three soil types. Pasture growth responses to nitrogen were reliable, being very high on Okaihau Gravelly Loam and Wharekohe Silt Loam soils.

The addition of sulphur showed a good response on the Wharekohe soil, while the other soils showed poor responses. These responses appeared to be in line with soil test deficiencies. Applying sulphur in August versus September, or at both times, did not significantly change the pasture growth response. Dry conditions during autumn and winter, prior to the commencement of the trial, may have reduced overall sulphur responses.

Responses to potassium were also variable across soil types with a reasonable response on the Kaipara Clay and poor responses on the other soil types, however it is acknowledged that it is likely this study did not measure the full potassium response.

Within this study, nitrogen applications were the most cost effective means of boosting pasture growth. The benefit of adding sulphur and potassium was site specific. Increasing application rates of nitrogen may be a more cost effective means of improving pasture production compared to adding other nutrients.

Acknowledgements

This study was conducted with funding from Northland Dairy Development Trust, thanks to the support of sponsors. Thanks to Duncan Bayne for conducting the trial. Thanks to NARF, Chestnut family and Okaihau Pastoral Ltd for providing trial sites. Special thanks to NDDT trustees Kerry Chestnut, Kim Robinson and Terence Brocx for trial oversight.

Northland's Diversified Forage Production

NORTHLAND'S DIVERSIFIED FORAGES

PROJECT OVERVIEW – JUNE 2020
Our objective has been to increase the profit and resilience of Northland farmers through identifying and exploiting forage solutions that demonstrate advantages in yield, feed quality and/or time of growth.

KEY POINTS

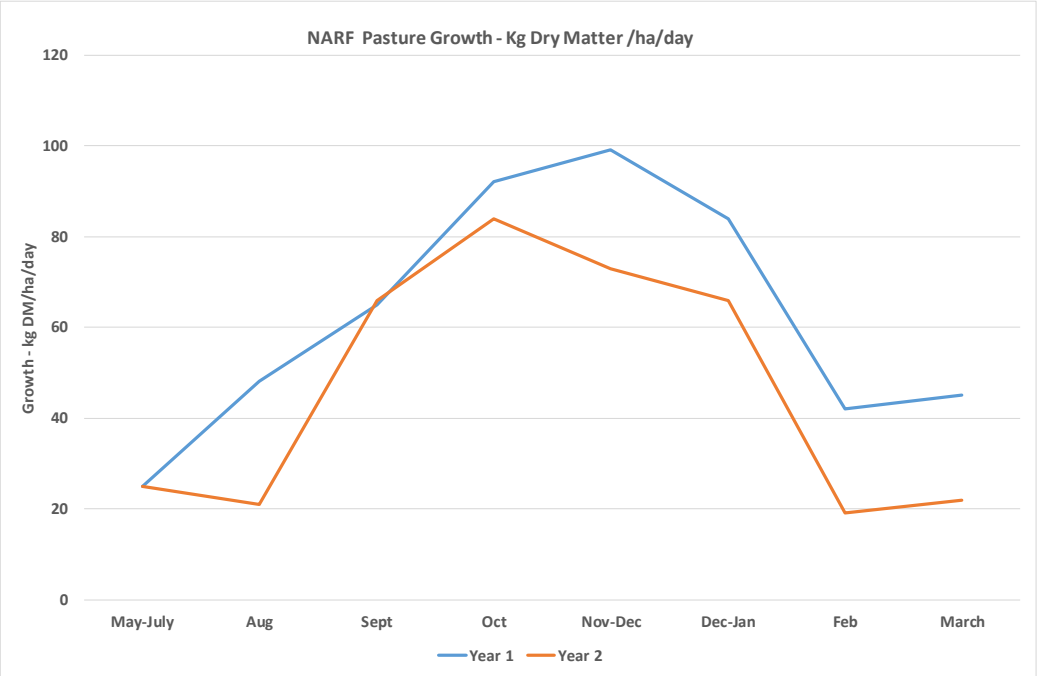
- Perennial ryegrass has limited persistence in Northland, especially on very dry soils.
- Cocksfoot and tall fescue are showing greater growth within the second year, compared to ryegrass.
- There are a number of species that offer yield advantages at times of the year when that additional pasture is very valuable:
    - Annual clovers August to December
    - Red clover December to April but there does need to be good soil moisture to capture most of its potential growth

- Plantain is very complimentary to a range of systems and soils in Northland
- It is critical to use high quality seed
- We have observed tremendous variation in yield results from forages, across farms – due to all the factors that makes each farm unique.

RESULTS – Mixes in Plots
Three sites with plot trials have had two years' monitoring. Plots were sown into perennial ryegrass or tall fescue or cocksfoot + white & red clover + an annual clover.

NARF Details
2018/19
An average of 20 tonne of DM/ha across all treatments driven by very high growth rates from annual clovers and the red clover. The combined clover yield was 17.3 t DM/ha @ 86% of total yield.

2019/20
An average of 15.4 t DM/ha being a drop of 4,670 kg DM/ha @ 23%, compared to 2018/19.



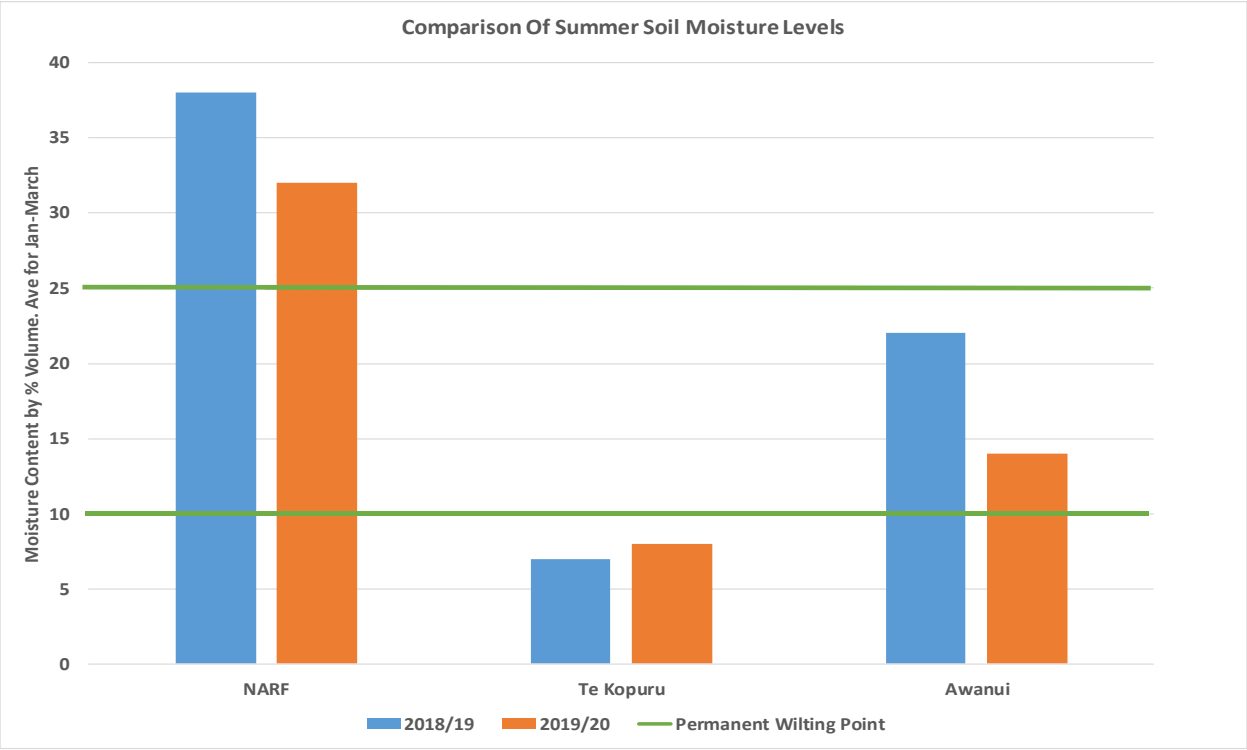
What caused this drop? Drought?

The drought, or "relatively dry conditions" accounted for only 50% of the reduction. The other 50% occurred before mid-January, caused by:

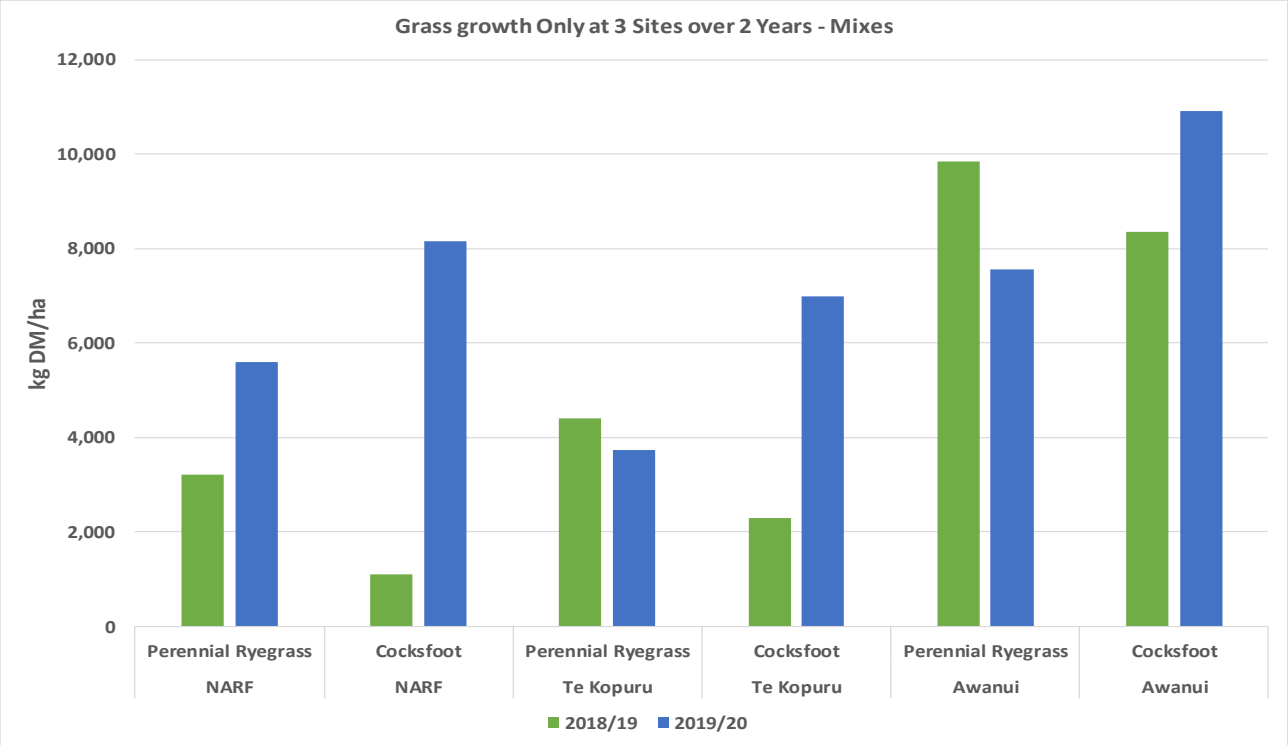
- Annual clover which averaged 7.7 t DM/ha in Year 1 was not present in Year 2
- Reduced red clover production in Year 2 in Nov, Dec & Early-Jan
- Increased grass growth in Year 2 did not make up for the reduction by other species.

Soil Moisture Impact

Very low soil moisture levels have had a major impact on the growth and persistence of the perennial ryegrass.



Soil moisture at NARF has been above the permanent wilting point (PWP): This PWP is estimated at 25 for the clay at NARF and Awanui, and at 10 for the sand at Te Kopuru. Plant death will occur with soil moisture being below PWP, for a period!



The same mixes were sown at the 3 sites, autumn 2018.

Points – Grass Growth Only:

- The ryegrass increased production between years at NARF, but decreased at the 2 very dry sites
- Cocksfoot has increased at all 3 sites from very different base production levels in Year 1 at all 3 sites.
- In Yr 2 across 3 sites, cocksfoot averaged 8,288 kg DM/ha compared to 5,538 for perennial ryegrass and 8,152 kg DM/ha for tall fescue.
- While the Yr 1 growth from the cocksfoot is low for NARF and Te Kopuru, it was affected by a low sowing rate of viable cocksfoot seed. In the data below, for the Control grass Plots, cocksfoot in Yr 1 grew 12,800 kg DM/ha at the Te Kopuru site: Somewhat higher than the 2,280 for the above result.

RESULTS: Control Grasses Plots

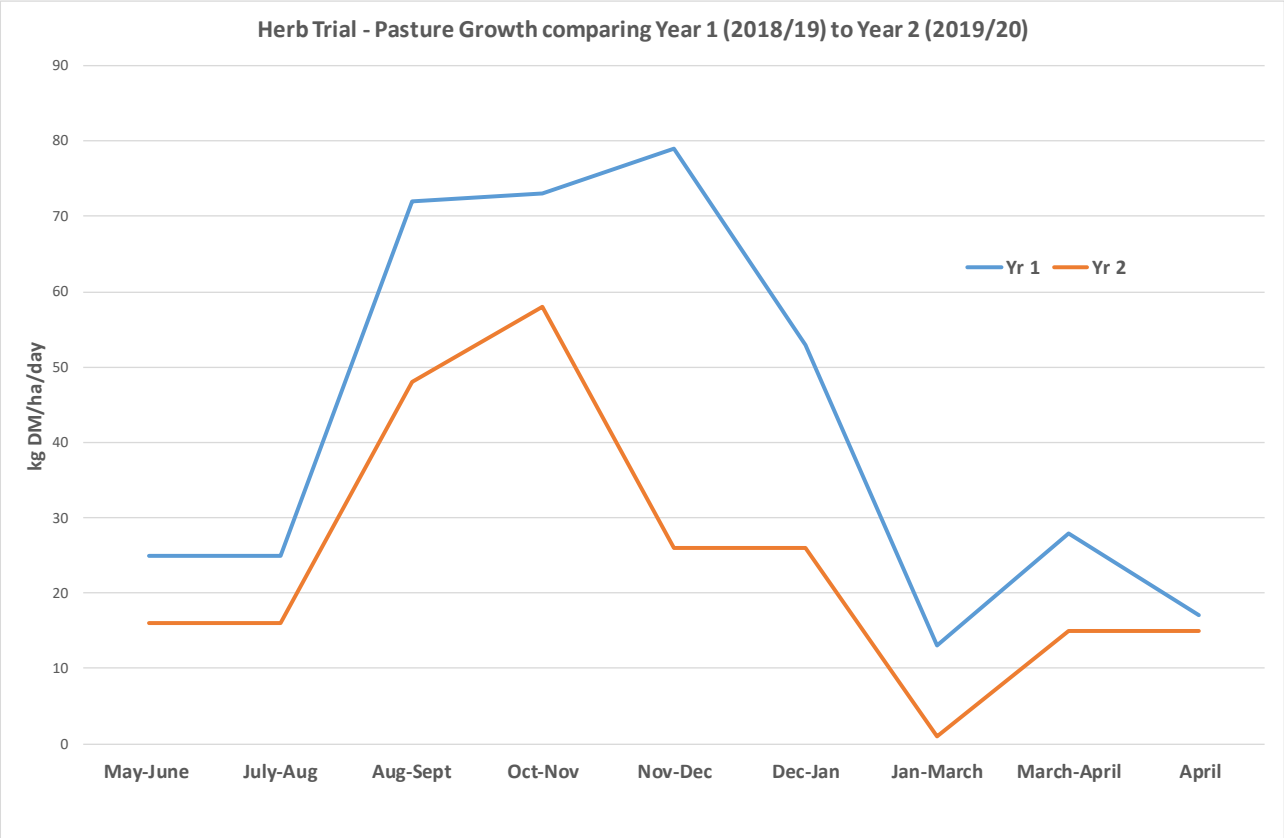
Two sites had plots sown into perennial ryegrass, tall fescue or cocksfoot + white clover, autumn 2017.

- Year 1 2017/18 Yields were similar @ around 16 tonne DM/ha
- Year 2 2018/19 With a dry summer and autumn, a decline in total pasture yield, by24% In the ryegrass.
- Year 3 2019/20 By the end of this Year 3, May 2020, ryegrass presence and contribution to yield was 12% on the clay site, fall fescue was 87% and cocksfoot was 80% on the clay.
- For Year 2 and Year 3, cocksfoot yield was 40% greater (3.5 tonnes DM/ha/year) than the perennial ryegrass on the clay soil.

HERBS VS NO HERBS

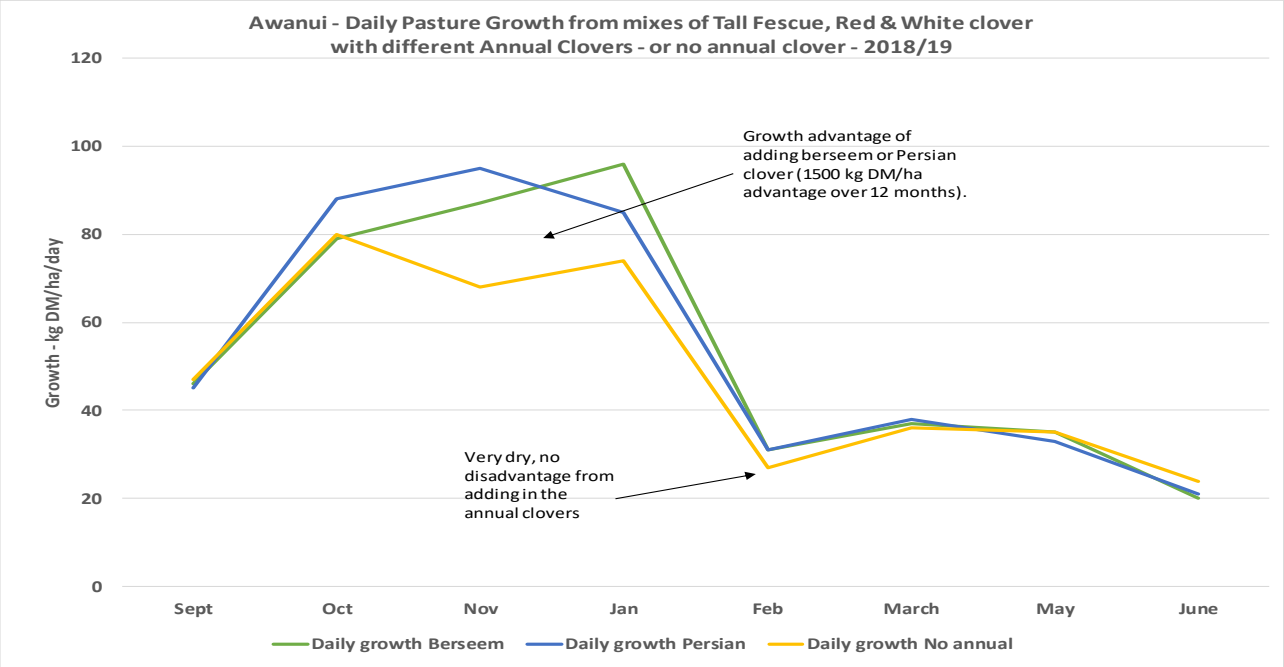
In Year 1, 2018/19, there was a major growth advantage of adding herbs, being plantain and chicory. While the plantain and chicory contributed 5,715 and 2,735 kg DM/ha respectively for the first year, the net growth advantage to this treatment was 2,413 kg DM/ha. The full 12 months' production for the *Plus Herbs* was 15,990 kg DM/ha compared to 13,578 for the *No Herbs*.

A large reduction in overall growth in Year 2, up to May 2020, with most of this reduction occurring before the drought.



Herbs Trial - Change in Growth Between Years: kg DM/ha			
	Year 1	**Year 2**	**Change in Growth**
Annual clover	4,964	0	↓ 4,964
Red clover	2,455	787	↓ 1,668
Plantain	5,715	3,602	↓ 2,113
Chicory	2,735	2,773	↑38
White clover	1,280	35	↓657
Sown grasses	1,893	4,435	↑ 2,542
A reduction of 6 tonne DM/ha in yield in Year 2 (2019/20) compared to Year 1, across all treatments.			

Annual Clovers – Their growth occurs before we get into our summer dry period. Persian and berseem annual clovers have their peak growth in Oct-Nov.



The Berseem result above is the average of the ryegrass, tall fescue and cocksfoot that had berseem as the annual clover. The *no annual* is the average of all treatments that had no annual clover sown, but had the same grass, white and red clover sown.

2019 Results – Peak Growth Kg DM/ha/day				
	Early October to Early/Mid-Nov		**Early/Mid-Nov to Mid-Dec**	
	Clay Soil	**Sand Soil**	**Clay Soil**	**Sand Soil**
Persian clover only	101	85	70	104
Perennial grasses, plantain and clover	85	83	54	75
Italian ryegrass, plantain and clover	90	52	52	65

FUTURE

This project has identified that there is potential for other species to be complimentary to Northland's current pasture species grown in Northland. Work needs to evolve looking at *best practice* establishment and management for various sites, various farm systems and differing pasture types.

Northland's Diversified Forages project is funded by Ministry of Primary Industries.
Co-funding support is provided by Hine Rangi Trust, T R Ellett Agricultural Research Trust, Ballance Agri-Nutrients, Northland Dairy Development Trust, Sweetwater Farms, Agricom, Foundation of Arable Research, Clover Consultancy, Eurofins, Northland Seed & Supplies, PGG Wrightson Seeds.