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Pasture Growth Response in Northland to Nitrogen, Sulphur and Potassium

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Summary

This study investigated pasture growth responses to adding sulphur (S) and potassium (K) to nitrogen (N) applications during late winter and early spring across three soil types in Northland. The initial study was conducted in 2019 during a relatively dry winter/spring and then repeated in 2022 when soil conditions were much wetter for extended periods.

Pasture growth responses to N varied between soil types and between years. Averaged across the two years, the Kaipara Marine Clay sites showed a 21:1 response (additional kg DM grown/kg N applied), the Wharekohe Silt Loam sites 18:1 and Okaihau Gravelly Loam sites 35:1.

The addition of S showed a good response on the Wharekohe soil with an average across the two years of 20:1 (kg DM/kg S applied), while the other soil types showed poor responses, averaging 3:1. These responses were in line with deficiencies observed in soil tests. Applying S in August versus September, or at both times, did not significantly change the response.

Responses to K were also variable across soil types with a reasonable response only on the Kaipara Marine Clay sites (average 9 kg DM/kg K applied) and poor responses on the other soil types (average 1:1). These responses on the Kaipara Marine Clay sites were despite soil tests showing adequate K levels. It is noted that potassium may have provided a longer lasting effect than measured in this study. There was no observed increase in clover content as a result of K application.

Within these studies, N applications were the most cost effective means of boosting pasture growth during late winter/early spring, other than on the Wharekohe soil type where in the 2022 study the addition of S improved the cost effectiveness of the N and S combination. Soil chemical tests were not a reliable means of determining pasture growth response to K applications in this study.

These studies indicate that maximising use of Nitrogen may commonly be a more cost effective means of increasing pasture production compared to adding other nutrients. Farmers should review previous elemental sulphur applications and/or sulphur soil test levels before choosing to apply S in late winter/early spring.

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.

Farmers may be adding these elements unnecessarily, or may be missing out because they are not including these elements. These trials tested pasture growth responses to nutrients that farmers commonly apply during late winter and early spring on a range of soil types in Northland.

Trial Design and Methods

Two studies were conducted on three sites/soil types, being a Kaipara Marine Clay (location Dargaville and Ruawai), a Wharekohe Silt Loam (location Kokopu) and a Okaihau Gravelly Loam (location Okaihau). The first study was undertaken in winter/spring of 2019 following a relatively dry autumn and winter. Concern that the results may have been affected by the dry conditions, the study was repeated in 2022 after a wetter autumn and winter. Table 1 shows the treatments applied during both studies on all soil types.

Table 1. Treatments applied to plots in early August and mid-September in studies conducted in 2019 and 2022.

Treatment Name	Early August Application/ha	Mid-September Application/ha
Control	Nothing	Nothing
N only (twice)	30 kg N (as Sustain)	30 kg N
N + S 1st Appl	30 kg N & 14 kg S (as Ammo 30N)	30 kg N
N + S 2nd Appl	30 kg N	30 kg N & 14 kg S
N + S Both Appl	30 kg N & 14 kg S	30 kg N & 14 kg S
N + K	30 kg N	30 kg N & 22 kg K (as MOP)
N + S 2nd Appl + K	30 kg N	30 kg N, 14 kg S & 22 kg K
N + S Both Appl + K	30 kg N & 14 kg S	30 kg N, 14 kg S & 22 kg K

Treatments at each site were replicated 5 times giving 40 plots/site. Plots were 2m x 4m on ryegrass dominant pastures. Plots were mown twice prior to the first treatment being applied. Pasture growth was monitored for four growth periods through cutting and drying pasture samples. A clover presence survey was undertaken prior to the final harvest.

Sites were soil sampled to a depth of 75mm for nutrient analysis at the time of the first treatment applications. Soil test results are shown in table 2.

Table 2. Average of two soil chemical 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 S	Potassium	Nitrogen	Sulphur	Potassium
Kaipara Marine Clay 2019	6.2	62	7	18	37	0	0
Kaipara Marine Clay 2022	6.7	59	12	19	30	0	0
Wharekohe Silt Loam 2019	6.6	38	4	5	30	0	25
Wharekohe Silt Loam 2022	6.0	25	2	4	27	0	25
Okaihau Gravelly Loam 2019	6.0	30	23	7	120	68	45
Okaihau Gravelly Loam 2022	6.0	46	12	9	64	36	35
Medium Range	5.8-6.2	20-30	10-12	7-10			

Results

Rainfall during autumn and early winter 2019 was significantly lower than the historical average on all sites (prior to the commencement of the trial). Rainfall during autumn and winter 2022 was higher than average on the Wharekohe and Okaihau sites and close to the historical average on the Kaipara Clay site.

Tables 3 and 4 show the main treatment effects for the three sites (soil types) reported as kg dry matter per kg nutrient applied, as determined by the pasture growth difference when a nutrient was added. There were no significant interactions between nutrient application time and nutrient type, therefore the two single

sulphur application treatment responses have been amalgamated to simplify this data, as have been the three potassium treatment responses.

During the 2019 study, the response to nitrogen was greatest on the Okaihau Gravelly Loam, while in 2022 nitrogen responses were similar on both the Kaipara Clay and Okaihau Gravelly Loam sites. These responses were high compared with published nitrogen responses. In both studies >90% of the nitrogen response had occurred by the first harvest following application (29 – 40 days). At all sites and in both studies, the nitrogen responses were statistically significant (P <0.001).

Response to sulphur was negligible and/or unreliable on the Kaipara Clay and Okaihau Gravelly Loam sites. However, sulphur responses were consistent and relatively high on the Wharekohe Silt Loam site, especially in 2022 study. The greater sulphur responses in the 2022 study may be in response to the higher rainfall that season. Sulphur responses correlated well with soil tests, where the Wharekohe Silt Loam showed very low sulphate sulphur levels but good sulphur responses.

In both studies the response to potassium was greatest on the Kaipara Clay, with little or no response on the other two sites. This was surprising given the potassium levels in the soil chemical tests were high on the Kaipara Clay soil in both studies while the Wharekohe site showed low potassium levels in the soil tests, however showed no response to potassium.

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 during both studies. Both studies monitored pasture growth responses to potassium for 89 days after nutrient application, it is acknowledged that the effect of potassium may have continued to show after monitoring stopped.

The clover presence survey conducted during early summer of both studies showed no effect as a result of potassium application, however there was a trend (not statistically significant) for the control treatment (no nutrients applied) to have higher clover levels than the other treatments.

Tables 3 & 4. Main treatment effects – total response to nutrient applied (kg of additional DM grown/kg nutrient applied) for the three trial sites (soil types) for the 2019 study and the 2022 study.

2019 Study **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**

2022 Study **Kg DM/kg Nutrient Applied**	Kaipara Clay	Wharekohe Silt Loam	Okaihau Gravelly Loam	**Average All Soil Types**
Nitrogen	32.1	16.8	30.9	**26.7**
Single Application of Sulphur	-1.5	42.6	-8.3	**11.0**
Double Application of Sulphur	4.9	17.2	11.0	**11.0**
Potassium	9.0	-1.1	1.5	**2.7**

Tables 5 and 6 show the cost of nutrient based on pricing at September 2019 and September 2022 (including the cost of cartage and application at $160/tonne). The cost of additional pasture growth is then calculated based on the treatment responses. Where negative nutrient responses occurred the dry matter cost is not calculated.

There were large differences in the calculated cost of additional pasture growth between soil types driven by response differences. Averaging over all soil types in the 2019 study, nitrogen was approximately three times

more cost effective than sulphur or potassium. In the 2022 study the cost of nitrogen had increased to a greater extent than the cost of sulphur which contributed to the cost effectiveness of sulphur applications, being somewhat similar to that of nitrogen. Only on the Kaipara Marine Clay were potassium applications somewhat cost effective compared to nitrogen.

It should be noted that the response to sulphur or potassium was not investigated without the addition of nitrogen.

Tables 5 & 6. Cost of nutrient (applied) and calculated cost of additional pasture grown/kg DM using 2019 pricing and 2022 pricing (NR = no response).

2019 Study and Pricing	2019 $/kg Nutrient	Cost ($)/kg additional DM grown		
		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

2022 Study and Pricing	2022 $/kg Nutrient	Cost ($)/kg additional DM grown		
		Kaipara Clay	Wharekohe Silt Loam	Okaihau Gravelly Loam
Nitrogen	$3.39	$0.11	$0.20	$0.11
Single Application of Sulphur	$1.92	NR	$0.05	NR
Double Application of Sulphur	$1.92	$0.20	$0.11	$0.17
Potassium	$3.45	$0.38	NR	$1.18

Conclusions

This study investigated the response to adding sulphur and potassium to nitrogen applications across three soil types and over two climatically different seasons. Pasture growth responses to nitrogen were reliable, being high on Okaihau Gravelly Loam and Wharekohe Silt Loam soils in the dry year of 2019 and high on the Okaihau Gravelly Loam and Kaipara Marine Clay soils in the wetter 2022 study.

The addition of sulphur showed a good response on the Wharekohe soil, while responses on the other soils were unreliable. Sulphur responses were in line with soil test deficiencies. Applying sulphur in August versus September, or at both times, did not significantly change pasture growth responses. Sulphur responses tended to be greater in 2022, which was a wetter season than 2019. 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.

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.

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This report is a shortened version of the full paper. To access the full paper contact chris.boom@agfirst.co.nz