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THE EFFECT OF CONTROLLED RELEASE NITROGEN FERTILISER ON PASTURE PRODUCTION ON TWO DAIRY FARMS IN WHATAROA, SOUTH WESTLAND

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Abstract

A controlled release fertiliser was compared to a standard nitrogen fertiliser approach on two dairy farms in Whataroa, South Westland to determine if there was an effect on pasture production. Replicated plot trials were carried out on two dairy farms in the Whataroa district in spring 2018. Three treatments were compared, control, a controlled release fertiliser Smartfert® and a standard nitrogen fertiliser programme applied after every grazing. Smartfert® was applied at 135 kg/ha (60 kg N/ha), in combination with SustaiN nitrogen at 87 kg/ha (40kg N/ha) in one application. In contrast the standard nitrogen fertiliser programme of SustaiN was applied after every cut over a three month period at rates of 87 kg/ha (40 kg N/ha), 65 kg/ha (30 kg N/ha) and 65 kg/ha (30 kg N/ha) respectively. Pasture wet weight, dry-matter and nitrogen content was measured monthly over 4 months to determine pasture production and nitrogen uptake.

Introduction

Nitrogen (N) is the most widely applied plant nutrient and has been described as the most yield limiting (Bockman and Olafs, 1998). Nitrogen fertiliser is utilised by farmers throughout the season to ensure pasture growth meets animal feed demand (Blennerhassett *et al*. 2006). Nitrogen is generally applied in low rates (30-40 kg N/ha) as a readily available form such as urea, sulphate of ammonia (SOA) or di-ammonium phosphate (DAP) (Edmeades, 2015). Readily available N is at risk of being lost through denitrification, volatilisation, runoff or nitrate leaching (Shaviv, 2000). In South Westland high rainfall during late winter/early spring can increase the risk of nitrogen losses. Not only does this pose an environmental risk, but a loss of potential pasture production due to reduction in nitrogen use efficiency. Furthermore, near-saturated soils during this period can be prone to compaction damage (Laurenson *et al.* 2014) if fertiliser is broadcasted using land based equipment, further reducing subsequent pasture production.

One way to improve nutrient use efficiency and decrease environmental risks associated with N application is to utilise a controlled release fertiliser (Shaviv, 2000). Controlled release fertilisers are typically coated with inorganic or organic materials that regulate the release rate of the encapsulated fertiliser (Shaviv, 2000; Guinto *et al.* 2018). The use of a controlled release fertiliser allows farmers to spread nitrogen in one application avoiding additional applications post grazing where risk of N loss or soil compaction is high. Furthermore, application/labour costs are reduced as only one application is required.

The controlled release N fertiliser, Smartfert® is polymer coated, controlled release N fertiliser. Smartfert® has been demonstrated as a controlled release fertiliser through trials conducted by

Edmeades (2015) and Edmeades and McBride (2017). In these North Island trials, no reduction in total pasture production was found. However, these trials were looking at Smartfert® and urea treatments in isolation rather than Smartfert® in combination with a soluble nitrogen fertiliser. Guinto *et al.* (2018) looked at Smartfert® in combination with SustaiN in the Hawkes Bay, Rotorua and Northland and found no decrease in pasture production compared to SustaiN applied in three applications. With farmers interested in a controlled released nitrogen, but with no localised data to demonstrate its effectiveness, this trial was established. The aim was to determine if the controlled released fertiliser Smartfert® in combination with SustaiN could deliver similar spring pasture production as three monthly SustaiN applications in the high rainfall climate of South Westland.

Methods

Two replicated plot trials were established in July 2018 to determine if a "Smartfert® + SustaiN" programme (referred to as Smartfert® treatment) could produce similar pasture production as a standard "SustaiN" programme (referred to as SustaiN treatment) (Table 2). The trials were established on two dairy farms in Whataroa, South Westland. These sites will be referred to as Bowater (43˚10'25.5"S, 170˚22'27.2"E) and Honeydew (43˚15'50.3"S, 170˚19'58.6"E). The sites were selected as they represented different rainfall zones within the Whataroa district and have different soil drainage characteristics. Bowater site is an imperfectly drained recent fluvial soil (Manaaki Whenua Landcare Research, 2018) and is in a lower rainfall zone closer to the coast. In contrast, the Honeydew site is a well-drained recent sandy soil (Manaaki Whenua Landcare Research, 2018) in a higher rainfall zone, closer to the Southern Alps mountain range. Furthermore, the Honeydew site is a new pasture paddock consisting of ryegrass, plantain and clover. In contrast, the Bowater site was an older pasture consisting of ryegrass and white clover.

Site soil testing occurred in July 2018 prior to trial establishment. Soil fertility at both sites, as well as optimum ranges, is described in Table 1. To ensure there were no nutrient deficiencies 330 kg/ha SuperTen (0 9 0 10.5), 30 kg/ha SulphurGain pure (elemental sulphur) (0 0 0 90) and100 kg/ha muriate of potash (KCl) (0 0 50 0) was applied. Lime and kieserite (Magnesium Sulphate) (0 0 0 16 16) were also applied to the Bowater site at an application rate of 5 T/ha and 100 kg/ha respectively.

Table 1: Soil fertility at Bowater and Honeydew site. Optimum ranges from Roberts and Morton (2016).

Soil Test	Optimum	Bowater	Honeydew
pH	5.8-6.0	5.4	6.0
Olsen P (µg/mg)	20-30	26	34
Potassium (MAF QTK)	5-8	3	5
Sulphate-S (ppm)	10-12	9	6
Magnesium (MAF QT Mg)	8-10	6	12
Total N (%)	-	0.21	0.29

Treatments were applied on the 21st July 2018. Prior to treatment application the trial site was mowed to 1200-1400 kg DM/ha residuals. The treatments were replicated four times and applied to trial plots (1.5m x 4m) in a randomised block design. Treatments were control (no fertiliser), Smartfert® (Smartfert® + SustaiN), and SustaiN only (3 applications of SustaiN). Both treatments had a total of 100 kg N/ha applied. Treatments are described in more detail in Table 2.

Table 2: Application rates and timings of nitrogen on the Smartfert® and SustaiN treatment.

Treatment	Day 0	Day 49	Day 76
Control	-	-	-
Smartfert®	136 kg/ha Smartfert® 87 kg/ha SustaiN	-	-
SustaiN	87 kg SustaiN	65 kg/ha SustaiN	65 kg/ha SustaiN

Pasture cuts occurred using a lawn mower at 49 days, 76 days and 103 days post nitrogen application. Wet weight of the pasture was taken on site and a subsample of pasture was collected from the plots using shears and analysed for dry matter content (DM%) and nitrogen content (%) by RJ Hills Laboratories, Hamilton, New Zealand using the protocols described in Anderson (1996). Post pasture cuts at the 49 day and 76 day, application of SustaiN was applied to the SustaiN treatment at an application rate of 30 kg N/ha (Table 2). No fertiliser was applied to the control or the Smartfert® treatment plots.

Rainfall and soil temperature was collected at 9am each day during the trial period at both sites.

An analysis of variance (ANOVA) was used to evaluate statistical significance of pasture production (DM/ha), N% and therefore N uptake, using the Statistical Tool for Agricultural Research (STAR).

Results

Soil Temperature and Rainfall

For the duration of the trial the total rainfall was higher at the Honeydew site (927 mm) compared to the Bowater site (814 mm). Soil temperature at the start of the trial averaged 8˚C across both sites it climbed steadily through the trial period to 14˚C by the end of the trial. In July/August, the Bowater site was warmer than the Honeydew site by 0.5-1˚C. However by mid-September the temperatures at both sites were similar.

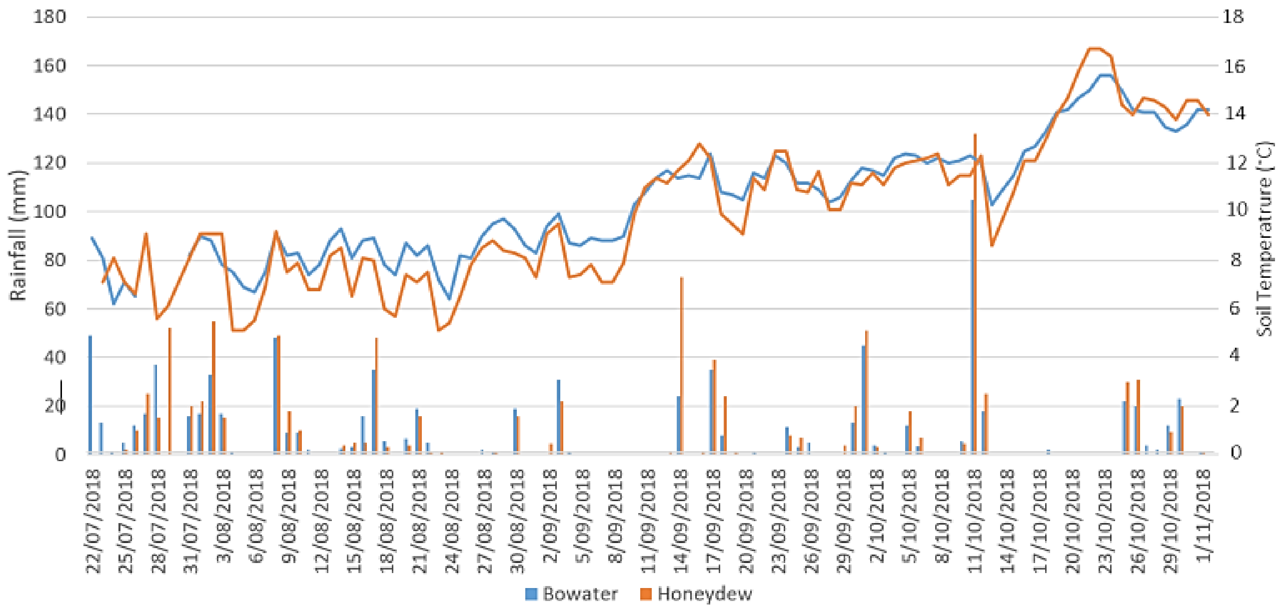

Figure 1: Daily soil temperature and rainfall for Bowater and Honeydew trial sites recorded at 9am each day.

Pasture Production (kg DM/ha)

At day 49 and day 76, treatments where nitrogen was applied had grown significantly more than the control at both Bowater and Honeydew (Table 3). However, there was no significant difference between the SustaiN treatment and the Smartfert® treatment. By day 103, the SustaiN treatment significantly outperformed the Smartfert® treatment by 885kg DM/ha and 506 kg DM/ha at the Bowater and Honeydew sites respectively.

Table 3: Bowater and Honeydew site pasture production (kg DM/ha) for control, Smartfert® and SustaiN. Treatments were applied on the 18th of July 2018. Letters indicate significance ($LSD_{0.05}$).

Treatment	Bowater				Honeydew			
	Day 49	Day 76	Day 103	Total	Day 49	Day 76	Day 103	Total
Control	502[b]	743[b]	1364[b]	2610[c]	808[b]	757[b]	1138[c]	2703[b]
Smartfert®	1282[a]	1479[a]	1571[b]	4331[b]	1312[a]	1407[a]	1644[b]	4363[a]
SustaiN	1041[a]	1506[a]	2456[a]	5003[a]	1296[a]	1557[a]	2123[a]	4976[a]
$LSD_{0.05}$	**401**	**114**	**410**	**563**	**340**	**296**	**196**	**697**

At the Bowater site, overall the SustaiN treatment grew significantly more than the Smartfert® and the control (Table 3). In contrast, at the Honeydew site there was no significant difference in pasture production between the Smartfert® treatment and the SustaiN treatment.

Nitrogen content and uptake

Nitrogen content of the pasture was significantly higher in the nitrogen treatments compared to the control at day 49 for both Bowater and Honeydew (Table 4). The Smartfert® treatment was significantly higher at 3.25% compared to the SustaiN treatment at 2.92% at Bowater. Similarly, at the Honeydew site the Smartfert® treatment had a significantly higher N content of 3.58% compared to the SustaiN treatment at 3.25%. In contrast, at day 76 there was no difference in any of the treatments at the Bowater site. However, at the Honeydew site the nitrogen treatments still remained significantly higher than the control. By the end of the trial, at day 103, both sites did not have any difference between the control, Smartfert® and SustaiN treatment.

Table 4: Bowater and Honeydew site nitrogen content of the pasture (N %) for control, Smartfert® and SustaiN. Treatments were applied on the 18th of July 2018. Letters indicate significance ($LSD_{0.05}$).

Treatment	Bowater			Honeydew		
	Day 49	Day 76	Day 103	Day 49	Day 76	Day 103
Control	2.60[c]	2.60	2.27	2.80[c]	2.67[b]	2.45
Smartfert®	3.25[b]	2.92	2.05	3.58[b]	3.12[a]	2.40
SustaiN	2.92[a]	3.05	2.10	3.25[a]	3.15[a]	2.50
$LSD_{0.05}$	**0.25**	**NS**	**NS**	**0.32**	**0.17**	**NS**

At the Bowater and Honeydew sites, nitrogen uptake was significantly higher in the nitrogen treatments compared to the control at day 49 and day 76 (Figure 2). However there was no difference between the Smartfert® and SustaiN treatment. At day 103, the Bowater site had higher N uptake in the SustaiN treatment compared to the control and the Smartfert®.

Furthermore, the Smartfert® did not uptake any additional N compared to the control. In contrast at the Honeydew site, the Smartfert® had significantly more N uptake than the control at day 103. However, the SustaiN treatment had a higher N uptake than the Smartfert® treatment.

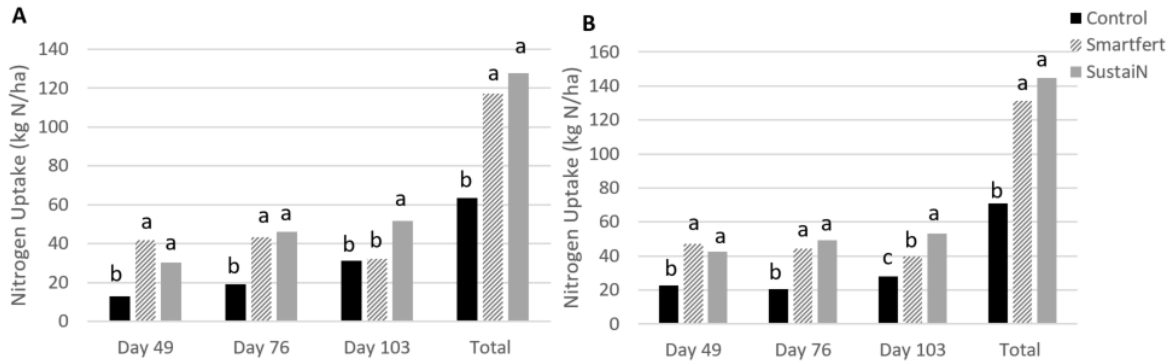

Figure 2: Nitrogen uptake at the Bowater (A) and Honeydew (B) sites for control, Smartfert® and SustaiN treatments at day 49, 76 and 103. Letters indicate significance ($LSD_{0.05}$). Note difference in X axis scale between A and B.

Discussion

At the Bowater site the total dry matter produced over the trial period was significantly higher in the SustaiN treatment compared to the Smartfert® treatment (Table 3). In contrast, the Honeydew site did not have a significant difference between the SustaiN and Smartfert® treatments. However, when determining the pasture production through the trial period (day 49, day 76 and day 103) it demonstrates that the Smartfert® and the SustaiN treatment grew similar amount of pasture up to day 76 across both sites. After this, at day 103, the SustaiN outperformed the Smartfert® treatment, indicating that the release of the Smartfert® was either not keeping up with plant demand or had fully released its 60 kg N/ha (in addition to the 40 kg N/ha in the SustaiN). Although N% was significantly higher in the Smartfert® treatment at day 49 (Table 4), it is unlikely that the full amount of N had been released in total during the trial period as the Smartfert® treatment did not produce significantly more than the SustaiN treatment at any of the cuts or overall. It is therefore, more likely that the remaining N in Smartfert® was being released after day 76 at a lower rate than plant demand and is potentially continuing to be released at low rates post day 103.

In order for farmers to budget for spring feed supply the “Smartfert®” programme must continue to supply similar pasture production as a traditional SustaiN programme of N post grazing. Both sites continued to have a non-significant difference between the SustaiN treatment and the Smartfert® treatment up to day 76. Indicating a similar feed supply up to this period. However, after day 76, differences in dry matter content occurred with SustaiN growing significantly more than the Smartfert® treatment. Furthermore, at the Bowater site the Smartfert® treatment did not grow any more than the control (no N fertiliser) treatment at day 103. This demonstrates that in the high rainfall environment of Whataroa a more soluble form of nitrogen, such as SustaiN, may be required to maintain pasture production at animal demand after 76 days. It is suggested that farmers utilising Smartfert® programme monitor pasture growth to identify if additional soluble nitrogen is required after 76 days post application. Due to the variability in climate in the Whataroa region, changes to the release pattern of the Smartfert® may change with soil temperature and soil moisture within seasons and year to year.

The differences in site response to Smartfert® indicate that there may be site specific variation which can cause the Smartfert® to release at differing periods (Edmeades, 2015; Edmeades and

McBride, 2017; Guinto *et al.* 2018). In addition, the well-drained soil at the Honeydew site, in combination with the higher rainfall, may be more advantageous for a controlled release fertiliser due to the impact of leaching potentially reducing the N response in the SustaiN treatment.

The N% of the pasture was significantly higher in the Smartfert® treatment compared to the SustaiN treatment at day 49. After this there was no significant difference between the two nitrogen treatments. This could indicate that in the Smartfert® treatment, the Smartfert® released an additional amount of N over and above the 40 kg N/ha of readily available N supplied as SustaiN. However, this additional N was not realised in the pasture production (Table 3) or the N uptake (Figure 2).

Overall at both the Bowater and Honeydew site the total N uptake was significantly higher in the Smartfert® and SustaiN treatments compared to the control (Figure 2). However there was no significant difference between the Smartfert® and SustaiN treatments. This indicates that the nitrogen released by both the Smartfert® and SustaiN treatments has been taken up in similar quantities by the pasture. Across all days and treatments the Honeydew site had higher N content (Table 4) and N uptake (Figure 2) than the Bowater site. The Honeydew site was a new pasture containing plantain. Research has suggested that plantain effects the nitrogen cycling of a soil through natural nitrification inhibitors retaining more nitrogen in the ammonium form and therefore reducing N losses via leaching and denitrification (Dietz *et al.* 2012; Luo *et al.* 2018). The Honeydew site could have retained more N in the mobile form to allow it to be up taken by the pasture. However, this N was not converted to higher amounts of pasture production with the sites having similar amounts of pasture grown over the trial period.

Conclusion

Total pasture production treatment differences were variable between the two sites. However, up to day 76 there was no significant difference between the Smartfert® and SustaiN treatment at both Bowater and Honeydew site. It is therefore suggested that farmers looking to utilise a Smartfert® programme in spring track pasture supply to determine if additional soluble nitrogen is required after 76 days to maintain pasture production at animal demand.

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