Pasture and tussock responses to a single application of nitrogen or a full development process for drier hill country over two years

B.R. THOMPSON[1] and D.R. STEVENS[1]

[1]*AgResearch Ltd., Invermay Research Centre, Private Bag 50034, Mosgiel*

bryan.thompson@agresearch.co.nz

Abstract

Increasing production from drier hill country to maintain economic viability must be balanced with environmental impacts and the preservation of the tussock landscape. This trial investigated the use of a one-off autumn application of nitrogen (100 kg N/ha) to increase pasture production from drier hill country over subsequent seasons while maintaining the tussock biota. Comparative control and previously oversown blocks were included. The response to nitrogen in the first winter-spring period was approximately 13 kg DM/kg N applied with no measurable response occurring thereafter. The oversown block produced around 3200 kg/DM/annum more than the other blocks, as expected in the first two years. The botanical analysis showed that browntop reinvasion of recently oversown pasture was rapid, increasing to a presence of over 50% in three years. Tussocks decreased in size in the nitrogen treated block but this was possibly due to management practices rather than a response to fertiliser nitrogen. This trial highlights some of the issues that surround the optimal use of nitrogen fertiliser in drier hill country and also documents the invasion of less desirable grasses into the preferred developed pastures.

Keywords

Nitrogen, tussocks, oversowing

Introduction

Pasture production from hill country can be increased through a multitude of practices which have been demonstrated on farms since European settlers arrived in this country. In considering a development strategy, farmers have to balance the societal and regulatory responsibility of limiting their environmental footprint and maintaining the aesthetic value of the landscape while ensuring they operate a profitable business.

Oversowing with preferred grass and legume seed has long been used to increase pasture production from hill country. Herbicides have been used in recent times to eliminate competition from naturally occurring grass and scrub species to improve the chance of seed survival and establishment. This method also eliminates the endemic tussock and scrub species which can be beneficial for stock as shelter particularly during the lambing and calving seasons (Pollard 2006).

Another approach that farmers can use to increase pasture production while maintaining the tussock and scrub cover is the tactical use of nitrogen. When applied during the autumn to early spring period it has been demonstrated to provide a range of increases in pasture productivity in hill country (Gillingham *et al.* 2007; Lambert & Clark 1986; Lambert *et al.* 2003; Ledgard *et al.* 1983). The effect on pasture growth depends on the timing of application in regards to initial and residual responses, but generally the response occurs over the first two to three months (Ledgard *et al.* 1983; Luscombe 1980; O'Connor & Gregg 1972; Sherlock & O'Connor 1974; Smith *et al.* 2000). Recent research undertaken as part of the Wise Use of Nitrogen research program indicated that increases in pasture productivity from nitrogen application could be detected up to 18 months after application.

This demonstration was set up in conjunction with the South Canterbury /North Otago Deer Farmers Association Deer Focus Farm to investigate the effects on pasture and tussocks of a single application of nitrogen over a two year period. A double sprayed oversown block was also monitored as a comparison between development methods.

Materials and Methods

Sites

This demonstration was conducted across two sites, Whiterock Station (43°44’S, 171°10’E) (site one) and Waikari Hills Station (43°47’S, 171°12’E) (site two), both in the Rangitata Gorge, South Canterbury. At Whiterock Station, two blocks, one control and one nitrogen block (nitrogen 2008) (100 kg N/ha) were set up on 27 March 2008 to compare and monitor pasture growth, quality and composition on base pastures consisting of historical oversown grass and legume species interspersed with silver (*Poa cita*) and snow (*Chionocholoa rigida*) tussocks and matagouri (*Discaria toumatu*) scrub. The blocks were south-westerly facing and at an altitude between 600-700 m.a.s.l. with an average annual rainfall of approximately 700 mm. The blocks had received applications of sulphur super and lime previously and in

2004 received 0.5 T/ha of lime and 40 kg/ha of Maxi Sulphur super (5.1, 47.0, and 11.0 kg/100kg of P, S, and Ca respectively) to maintain soil fertility and pH. The nitrogen treatment was applied aerially using a helicopter during the autumn of 2008 when weather conditions were deemed to be suitable. At Waikari Hills, two blocks were set up on 27 May 2008 and consisted of an unimproved tussock control block and a fully developed oversown block adjacent to the control block. Blocks were north-westerly facing and ranged between 750-850 m.a.s.l. with an average annual rainfall of around 1000 mm. The oversown block was sprayed with two applications of glyphosate (4 L/ha, glyphosate 510 g a.i./L) in December and January 2006, oversown with rape and Italian ryegrass for winter and spring grazing and then sprayed twice more in late spring 2007 prior to sowing with a permanent pasture species mix of perennial ryegrass, cocksfoot and white clover. It was fertilised (250 kg/ha sulphur super) and limed (2 t/ha) to optimise pasture production.

Measurements

Pasture species composition was monitored over a two year period using three 30 m transect lines in each block. Transect lines on Whiterock Station were located adjacent to one another 30 m apart and ran upslope covering a range of vegetative cover to ensure a representative sample was monitored. The transect lines on Waikari Hills Station were selected to cover the dry ridge, mid slope and basin features of the respective blocks. The four most prominent pasture species present were recorded in order of dominance (1 being the most dominant to 4 being the least dominant) within a 5 cm radius at 1 meter intervals along the transect lines. This data allowed a frequency of occurrence to be calculated for statistical analysis. The base circumferences of tussocks were measured in centimetres when encountered. The species present were assessed at trial setup, spring 2009, and 2010 when the trial finished.

Pasture growth was monitored 6-weekly during spring, summer and autumn and once during mid-winter, using pasture cages excluding stock grazing with one cage per transect line. Pasture was trimmed to approximately 800-1000 kg DM/ha with clippings being removed. Growth rates were calculated using data obtained from a F400 electronic rising plate meter (Farmworks Ltd, Palmerston North, New Zealand).

Pasture quality samples were collected during growth measurements and were analysed by FeedTECH Ltd, Palmerston North, New Zealand using the standard NIR feed test.

Soil samples were collect three times during the trial coinciding with the transect line species recording. Soil cores were collected along the transect lines down to 7.5 cm and sent to NZ Labs for analysis for a standard elemental test.

Statistical analysis

As the site was primarily for demonstration, the transect lines and cages provided pseudo-replication within each block. The data was analysed using a random estimate of maximum likelihood (REML) analysis (Genstat 2011) with site being treated as a fixed effect and transect as the random effect. The change in pasture composition over time used a repeated measures in time analysis.

Results

The nitrogen treated block on Whiterock Station produced 1300 kg DM/ha more pasture than the control block during the first winter-spring period (late May-late October) (Table 1) resulting in an response rate of 13 kgDM/kg N applied. Similar pasture accumulation occurred for the following year for these two blocks. The Waikari Hills oversown block produced approximately 3200 kg DM/ha/year more than the other blocks in the trial, with the comparative unimproved (control) block producing around the same quantity of pasture annually as the Whiterock blocks. Average pasture production was different between the three slopes for spring ($P=0.038$), summer ($P=0.018$) and winter ($P=0.024$) on the Waikari Hills blocks.

The Waikari Hills oversown block had less browntop ($P<0.05$) and more ryegrass ($P<0.001$) than the other blocks. There was a trend to an increasing amount of browntop in the Waikari Hills oversown block occurring at 24% of the transect points initially and increasing to over 50% of the points at the last measure. There was also a trend to a decreasing amount of ryegrass (81% decreasing to 72%) over time. On Whiterock Station there was an increase ($P<0.05$) in the occurrence of ryegrass in the nitrogen treated block (18% increasing to over 58%) with the comparative control block increasing slightly but not significantly (44 to 69%). There was also a trend to a decrease in white clover content during the trial for both the nitrogen treated block and the comparative control block reducing from 48 to 31% and 67 to 61% respectively. Cocksfoot increased but not significantly in the Waikari Hills oversown block from 8 to 23% but did not differ in the other trial blocks.

Tussock total counts varied between blocks (P<0.05) ranging from 2.33 and 6.00 tussocks per transect line for the Whiterock nitrogen treated block and Waikari Hills control blocks respectively but there were no interactions with time. Silver tussock accounted for the majority of tussocks recorded accounting for between 81-92% of total tussocks encountered over the three recording periods. There was a decreasing linear relationship (P=0.029) over time for individual average tussock circumference (cm) in the Whiterock nitrogen treated block reducing from 162 to 7 cm. There was no change in size of snow tussocks during the same period demonstrating that all of the change occurred in the silver tussocks.

Pasture metabolisable energy contents (ME) were higher for the Waikari Hills oversown block (11.18 and 10.98 MJ/kg DM for year 1 and 2 respectively) than the control block (9.98 and 10.11 MJ/kg DM for year 1 and 2 respectively) in both years (P<0.001). There were no differences in pasture ME between the Whiterock blocks in year 1 (10.53 and 10.34 MJ/kg DM) or year 2 (11.09 and 11.21 MJ/kg DM). Pasture ME differed between seasons in year 1 (P=0.004) and year 2 (P<0.001) with the highest values recorded during spring (10.96 and 11.14 MJ/kg DM for year 1 and 2 respectively) and declining over summer and autumn and reaching their lowest values in winter 9.79 MJ/kg DM in year 1, no data for year 2). Pasture crude protein (CP) differed between the two Waikari Hills blocks in year 1 (20.67 and 24.15 g/100g DM for the control and oversown blocks respectively) (P<0.05) but not in year 2 (22.12 and 23.61 g/100g DM). Crude protein values did not differ between the Whiterock blocks within each year with values of 22.03 and 22.06 g/100g DM in year 1 and 24.43 and 24.79 g/100g DM for the control and nitrogen treated block respectively. There were no differences in CP values between seasons.

Soil tests indicated that the soil fertility was adequate and that a good response to nitrogen could be expected.

Discussion

The response to the first application of nitrogen is within the range described by Gillingham *et al.* (2007) and Smith *et al.* (2004) for similar environments. There were however no pasture production effects detected in the following autumn or in year 2 as demonstrated by previous work in the Wise Use of Nitrogen Western Southland trial. In the Western Southland demonstration the key responses were recorded during the spring periods when ewes and lambs were set stocked for lambing. In the first spring following the autumn application of 100 kg N/ha, the stocking rate increased by 64%, while in the second spring the stocking rate was still 37% higher, some 18 months after application. The winter management of intensive mob grazing by sheep may have provided a recycling of the fertiliser nitrogen at the Western Southland site, while the low impact set stocking at Whiterock did not.

The large increase in pasture production achieved in the Waikari Hills oversown block was as anticipated. The majority of extra growth occurred in spring and summer as would be expected due to the growth pattern of ryegrass.

The trend to an increasing occurrence of ryegrass and a decrease in legume in the sward of the nitrogen treated block is similar to other research findings (Gillingham *et al.* 2008; Ledgard *et al.* 1983; Smith *et al.* 2004). In general the change in occurrence of the legume in the sward is a direct result of the increasing amount of grass grown in response to nitrogen application. This increased grass growth competes with and shades the legume plant. The smaller response of the grass to nitrogen application in this trial could also explain the smaller reduction in clover content, as the same degree of competition and shading would not have resulted. This also highlights the importance of grazing management of the increased growth as an important factor in helping minimising the negative effect on clover content.

The trend to a decreasing occurrence of ryegrass in the sward on Waikari Hills oversown block indicates that the use and benefits from ryegrass in this hill country may be short lived which was also demonstrated by Chapman & Campbell (1986) in moist North Island hill country. To confirm this, further research lasting over an extended period of time would be required. The increase in the occurrence of cocksfoot in the sward from 8 to 23% demonstrates the relatively slow establishment of this grass species as described by Scott *et al.* (1995) but also indicates that cocksfoot may persist for a longer period of time in this environment when compared to ryegrass. To maintain persistence of cocksfoot it is important that grazing is rotational and at a low to moderate density (Scott *et al.* (1995).

Tussock numbers along the transect lines did not change significantly during the trial period but it must be noted that numbers were low, particularly for snow tussock, with a large variability between transect lines within any given block. It is not known at this stage whether the decrease in total size and individual size of tussocks in the Whiterock nitrogen treated block occurred due to management strategies at the site of the transects or whether the nitrogen made the tussocks more palatable for the grazing animals. It was noted that the area had been used occasionally as a feed out area during the winter but this may or may not have impacted on the tussocks. Further research is needed to determine this. Tussocks were not present on the Waikari Hills oversown block as a result of the application of herbicide during the development process, and as a consequence were excluded from the analysis.

There were no recorded effects on ME and crude protein content of pasture that had received nitrogen application over that of the control block. The pastures on Whiterock were generally of very high quality due to the grazing management utilised on these blocks so a change would not be expected. The increase in pasture quality in the first year for the Waikari Hills oversown may be a result of an increasing amount of ryegrass and white clover in the sward. The drop in quality in the second year is potentially a result of other grasses increasing in the sward.

In conclusion, farmers that choose to keep tussocks can use nitrogen to increase pasture production in the short term with the direct effects to the tussocks inconclusive at this stage. The oversowing program used in this trial does eliminate tussock but also increases pasture production significantly. There is an indication that this extra pasture production will diminish with time as the amount of ryegrass in the sward decreases due to the reinvasion of undesired grasses.

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Table 1. Pasture accumulation in kg DM/ha per season for the five blocks compared.

	2008 Winter	2008 Spring	2008-09 Summer	2009 Autumn	2009 Winter	2009 Spring	2009-10 Summer	2010 Autumn	2010 Winter
Waikari Hills Oversown	253	2854	3155	488	232	3160	4998	1290	1020
Waikari Hills Control	49	1200	2276	223	127	2143	3723	1039	927
Whiterock Control	16	726	1834	309	200	2565	2744	691	1053
Whiterock Nitrogen 08	159	1898	1800	319	221	2776	3007	489	776