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COMPARATIVE EVALUATION OF CONTROLLED RELEASE FERTILISERS FOR NITRATE LEACHING

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Abstract

A lysimetric study was carried out with an objective of evaluating the leaching behaviour of different fertilisers on spinach growth on Manawatu sandy soil. The fertiliser treatments applied were urea, two controlled release fertilisers called ‘g’and ‘SmartN’ at the rates of 50 kg N/ha (50N), 100 kg N/ha (100N) and 200 kg N/ha (200N). The 200 kg N/ha urea application was made in 10 split doses at a rate of 20 kg N/ha in 7-day intervals, whereas 200N application of ‘g’ and ‘SmartN’ were made twice at a rate of 100 kg N/ha at the time of planting and six weeks after planting. The control treatment did not receive any fertiliser application (0N). The application of Urea and ‘g’ at all rates except ‘g’-50N produced significantly higher nitrate leaching losses (19.8 to 27.7 kgN/ha) compared to the control (9.1 kgN/ha), while SmartN at all rates produced no significant increase in nitrate leaching. The total nitrate leached per ton of dry matter production was significantly reduced by the application of N fertilisers compared to the control (135.1 kgNO_3^--N/MgDM). On an average, 16.4 kg NO_3^--N/MgDM was leached from the fertilised treatments. Dry matter production increased at 200N application rates with all three fertilisers, but urea-200N produced the highest dry matter yield of 2377 kg/ha. In conclusion, frequent split applications of urea (urea - 200N) increased dry matter yield thereby significantly reduced nitrate leaching.

Keywords: Controlled release fertilisers, leaching, lysimeter, nitrate, SmartN.

Introduction

Global food demand is expected to continue to rise into the next two decades (Sattari *et al*. 2016). Yet, large gaps persist between typical farmer yields and attainable crop yields (Cassman *et al*. 2003). The key to narrow down this gap while minimising the environmental footprint depends on overall efficiency and effectiveness of nitrogen (N) fertiliser use. Freney (1997) emphasized that appropriate fertiliser N rate and the correct form and time of application of fertilisers is one of the ways to achieve fertiliser use efficiency. However, mismatched timing of N availability with crop demand is the reason for major N losses in cropping systems (Robertson and Vitousek. 2009).

The use of controlled-release N fertilizers may allow nutrients to be used more efficiently by plants than soluble N sources by reducing nitrate leaching losses and providing a constant supply of nutrients to the roots (Hauck, 1985; Mikkelsen *et al.,* 1993). Yet, their nutrient use efficiency and leaching behaviour need to be evaluated in relation to commercial water soluble fertilisers to recommend their applications on vegetable crops. The objectives of this study were to evaluate the effect of two different types of controlled release fertilisers in relation to conventional urea on nitrate leaching losses and net dry matter yield of spinach.

Materials and methods

A lysimetric experiment was carried out to evaluate the leaching behaviour of different fertilisers on spinach production growth on a Manawatu sandy soil from 16th August 2019–25th October 2019. Plastic buckets with an upper diameter of 25 cm, lower diameter of 19 cm and height of 23.5 cm were used in the experiment (Figure 1).

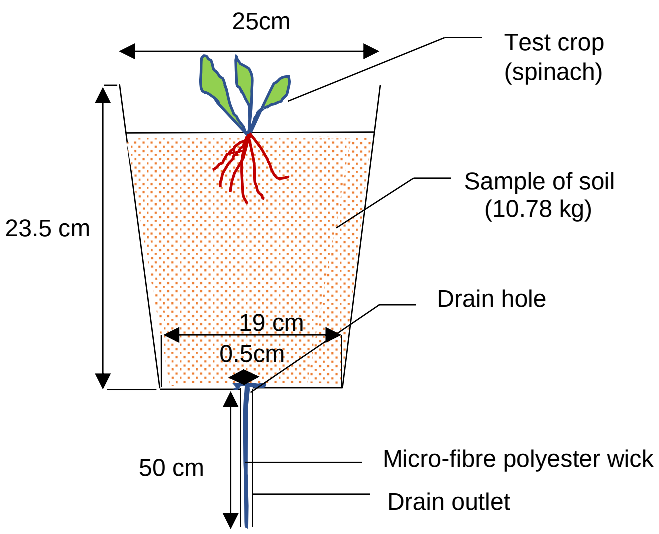

Figure 1. Design of the bucket lysimeter

Experimental design and treatments

Fifty lysimeters were filled with 10.78 kg of Manawatu sandy soils with added fertilisers according to the designed treatments (Table 1). The 200 kg N/ha urea application was made in 10 split doses at a rate of 20 kg N/ha in 7-day intervals, whereas 200N application of 'g' and 'SmartN' were made twice at a rate of 100 kg N/ha at the time of planting and six weeks after planting. The control treatment did not receive any fertiliser application (0 N). The lysimeters were arranged in a completely randomized design with five replicates per treatment and spinach seedlings were planted at 5cm depth in each lysimeter. Leachate samples from each lysimeter were captured in plastic cans. Leachate volume was determined when the cumulative rainfall exceeded 18mm and 10*ml* sample was retained for analysis of NO_3^--N and NH_4^+-N. The samples were frozen at -4^{o}C until analysis and all the samples were centrifuged at 5000 rpm for one hour to settle the suspended materials in the samples.

Table 1. Fertiliser treatments

Treatment	N application rate (kg N/ha)
Control (0N)	0
Urea (50 N)	50
Urea (100N)	100
Urea (200 N) – 10 split applications	200
'*g*' (50 N)	50
'*g*' (100 N)	100
'*g*' (200 N) – 2 split applications	200
SmartN (50N)	50
SmartN (100 N)	100
SmartN (200 N) - 2 split applications	200

Harvesting was done on 25th October 2019 by hand. Wet weight of harvested spinach leaves was recorded and then the samples were oven dried at 65˚C. The dry weight of samples were recorded.

Statistical analysis

An analysis of variance (ANOVA) was used to evaluate statistical significance of the cumulative nitrate loss and the dry matter yield in "SAS" software. The estimates of the least significant difference (LSD) among treatment means were reported at a confidence level of 95%.

Results and discussion

Leaching losses of N

There was a fertiliser treatment effect ($p < 0.05$) on NO_3^--N leached from fertiliser 'g', where more NO_3^--N was leached from the 100N and 200N treatments than the 50N treatment. The application of Urea and 'g' at all rates except 'g'-50N produced significantly higher nitrate leaching losses (19.8 to 27.7 kgN/ha) compared to the control (9.1 kgN/ha), while SmartN at all rates produced no significant increase in nitrate leaching.

There was no significant difference among the fertiliser rates on cumulative NO_3^--N leached from urea and smartN (Figure 2). However, there was a trend that under the smartN treatments, losses were generally lower than urea and 'g' treatments. Cumulative NO_3^--N leached from 200N treatments equated to 19.8, 29.5 and 15.8 kg/ha from urea, g and smartN fertilisers respectively. The greatest amounts of NO_3^--N were found to be leached from 'g' 200N treatment. On an average 9.1 kg of NO_3^--N was leached from the control treatments due to mineralisation of soil organic matter as reported by Goulding (2000).

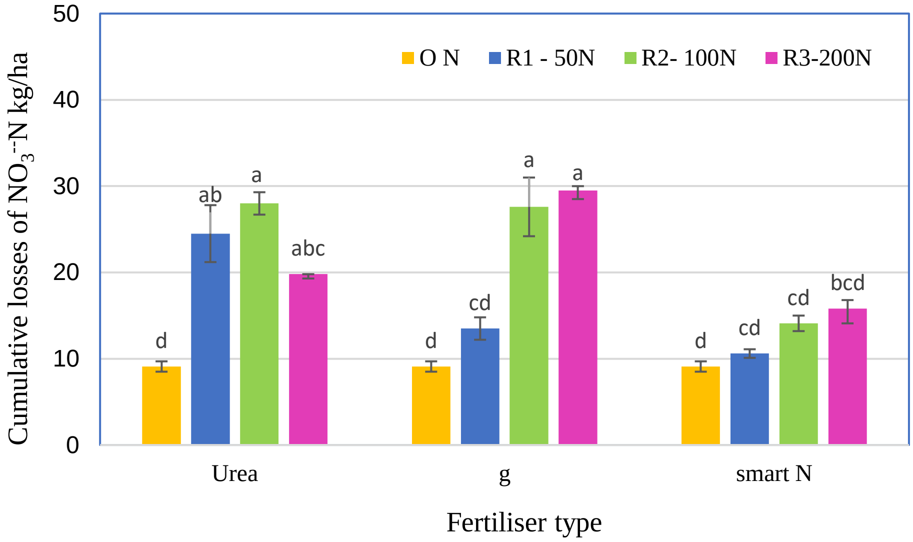

Figure 2. Cumulative losses of nitrate nitrogen

Dry matter yield

Dry matter (DM) yields from the fertiliser treatments were greater ($p < 0.01$) than those from the control treatments. Across the fertilised treatments, there was no difference in yield between the 100N and 200N rates with urea and 'g'. The highest yields were obtained by urea and 'g' greater than or equal to100N, while for SmartN, the maximum yield of 1601.2 kg/ha was obtained at 200N (Figure 3). Even though, dry matter production increased at 200N application rates across all three fertilisers, there was a notable increase in DM yield of 2377 kg/ha at urea-200N but there was no difference in yield at 50N fertiliser rates across the three fertilisers.

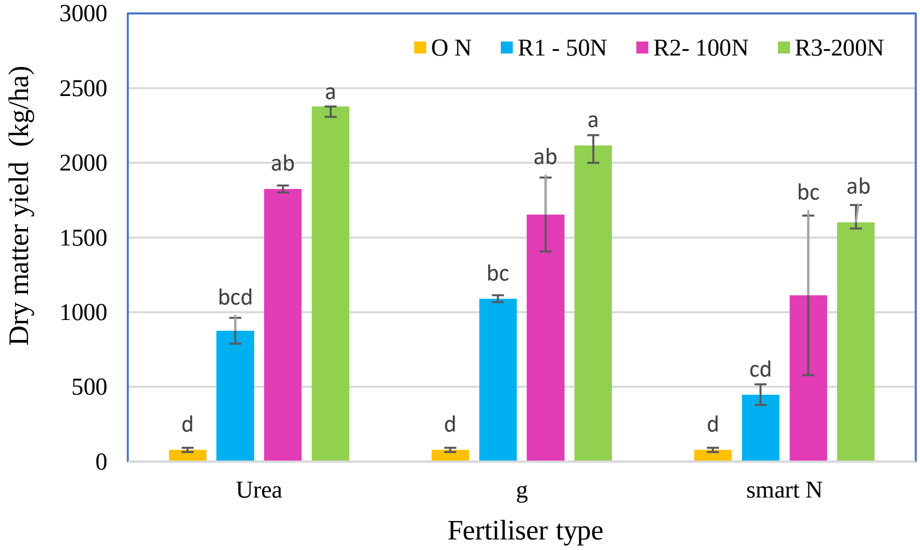

Figure 3. Dry matter yield at different fertiliser rates

The total nitrate leached per ton of dry matter production was significantly reduced by the application of N fertilisers compared to the control (135.1 kgNO_3^--N/MgDM). On an average, 16.4 kg NO_3^--N/MgDM was leached from the fertilised treatments. Frequent split applications of urea (urea - 200N) reduced nitrate leaching by 93.7% (Table 2).

Table 2. Estimated reduction in NO_3^--N leached from control versus fertiliser treatments

Treatment	*Cumulative nitrate loss (kg N/ha)	*Dry matter yield (kg/ha)	*Cumulative Nitrate loss (kg/Mg DM)	% reduction in losses
Control (0N)	9.1	78.0	135.1[a]	-
Urea (50 N)	24.5	875.6	30.3[b]	55.1
Urea (100N)	28	1824.8	16.0[b]	88.1
Urea (200 N) – 10 splits	19.8	2376.8	8.5[b]	93.7
'*g*' (50 N)	13.5	1090.4	12.5[b]	90.7
'*g*' (100 N)	27.6	1654.0	18.5[b]	86.3
'*g*' (200 N) – 2 splits	29.5	2116.0	11.4[b]	91.5
SmartN (50N)	10.6	448.0	26.3[b]	82.7
SmartN (100 N)	14.1	1112.4	13.6[b]	90.0
SmartN (200 N) - 2 splits	15.8	1601.2	10.0[b]	92.6

** Average of 5 replicates*

Conclusion

NO_3^--N leaching losses were influenced by the fertiliser type and frequency of application. Two split applications of 100 N as 'g' was equivalent to the single 100 N application of urea in terms of nitrate leaching losses. Frequent split applications of urea (urea-200N) increased dry matter yield thereby significantly reduced nitrate leaching.

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