DOES SIZE MATTER?

THE EFFECT OF URINE PATCH SIZE ON PASTURE N UPTAKE

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Background

A urine patch can be considered as the area wetted directly by the urine deposition (a 'wetted area', or as an 'effective area', which also includes a zone outside of the urine patch where the pasture is able to access urinary N by lateral growth of roots or diffusion of N (Buckthought, 2014). Recent urine studies reported by Phillips & Shepherd (2013) used micro-plots (0.36 m^2) with unconfined edges to mimic urine patches N loading of 600-800 kg N/ha). These showed that the edge effect (extra pasture growth) extends 10-15 cm around the wetted area which effectively doubles the visual size of the patch. They also reported an increase of (up to) 40% in N uptake from urine N deposited in the wetted area when uptake from the edge of the urine patch is included. This varied with application time, being less in winter.

Size becomes important when considering edge contribution to uptake because the smaller the urine patch, the greater the relative contribution that edge uptake could make. The aim of this study was therefore to assess the interaction of urine patch size and N loading on pasture N uptake and, by inference, N leaching risk.

Method

A small plot study was set up in March 2014 in an area that had previously been fenced for three months to exclude animals. The study site was on a Bruntwood soil series located at the Ruakura Research Centre. Topsoil texture was clay/clay loam. Bulk density measurements taken from the trial site gave an average of 0.91 g cm^{-3} (0-90 cm).

A plot study was set up in March 2014, where small pasture plots representing urine patches were divided into three zones: wetted, where urine was applied directly; edge, where there was a zone of visible extra growth adjacent to the wetted area (15 cm); and outer (unaffected) as a control.

The experiment was a 3 x 3 factorial design and treatments were allocated in a pseudo randomised block format with 5 blocks. Factors were:

- patch size (0.2 m^2, 0.36 m^2 and 0.49 m^2) and
- N application rate (400 kg N ha^{-1}, 700 kg N ha^{-1} and 1000 kg N ha^{-1}).

Total plot sizes including wetted area, edge and outside 'zones' were thus 1.8 m^2, 2.25 m^2 and 2.7 m^2, with a minimum 0.6 m buffer between plots. Treatments were applied after the pasture had been mown to simulate a residual height of about 5 cm. Application date was 18th March 2014.

Movement of N from the patch was measured by harvesting the three 'zones' of the plot separately. Following the initial uniformity cut, pasture yield was harvested by mower approximately 6 weekly to determine pasture response. Herbage samples were taken from each plot to determine % dry matter (DM) and %N.

Results

The months preceding the start of the experiment were extremely dry. However, regular watering of the site in the six weeks before the experiment enabled the pasture to recover. Gravimetric soil moisture content (0-75 mm) was 35% at the start of the experiment, decreased to about 20% in the early stages but the soils rewetted and were at or close to field capacity (about 45%) in mid-April following heavy rain. May and August was drier than average, June was wetter than average, July was average (Figure 1).

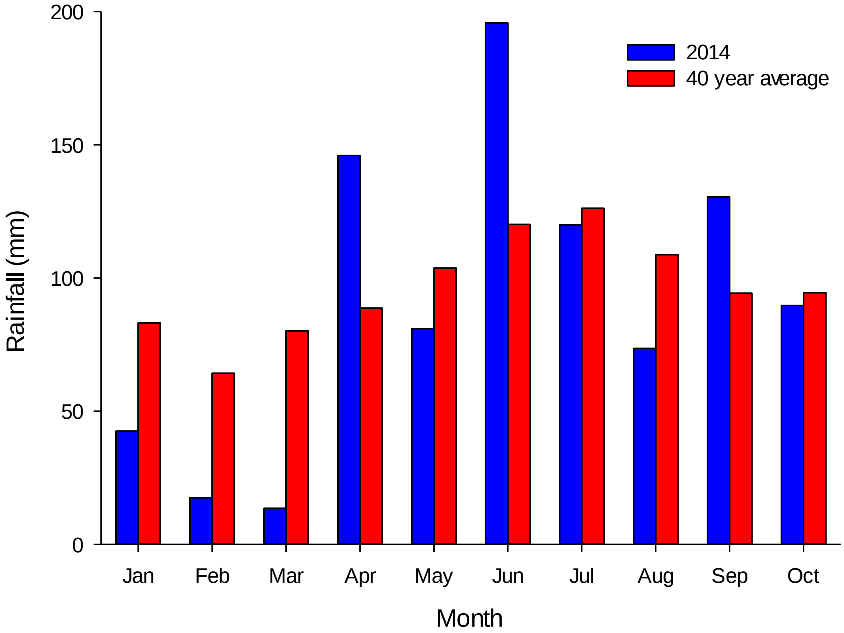

Figure 1: *The measured monthly 2014 rainfall and the 40 year average.*

Pasture yield and N uptake

The total pasture DM yield over 4 harvests in the absence of urine (outside zone) was 3.2 t DM ha^{-1}. Yield in the edge zone was 5.0 t DM ha^{-1}; and 7.4 t DM ha^{-1} in the wetted area.
The contribution from the edge zone to the total net N uptake was only significantly affected by urine patch size, not N rate (Table 1). About 40% of total net N uptake occurred in the edge zone in the small patch and about 30% for the medium and large patches. Expressed relative to the wetted area, the edge area net N uptake was equivalent to 68% of the wetted area uptake for the small patch; and 43% and 40% for the medium and large wetted areas respectively. The contribution of the edge zone to net N uptake relative to the wetted area was linearly related to the size of the edge zone relative to the wetted area (Figure 2). The slope of the relationship suggests that the edge zone is, on average about 40% as efficient as the wetted area in accessing urinary N.

Table 1: *Contribution of the edge to N uptake in the patch as % of total uptake (patch + edge), and as % of wetted area. *** P<0.001, ** P<0.01, * P<0.05, - Not significant.*

Edge contribution	As % of total	As % of wetted area
Rate	-	-
Size	***	***
Rate x Size	-	-

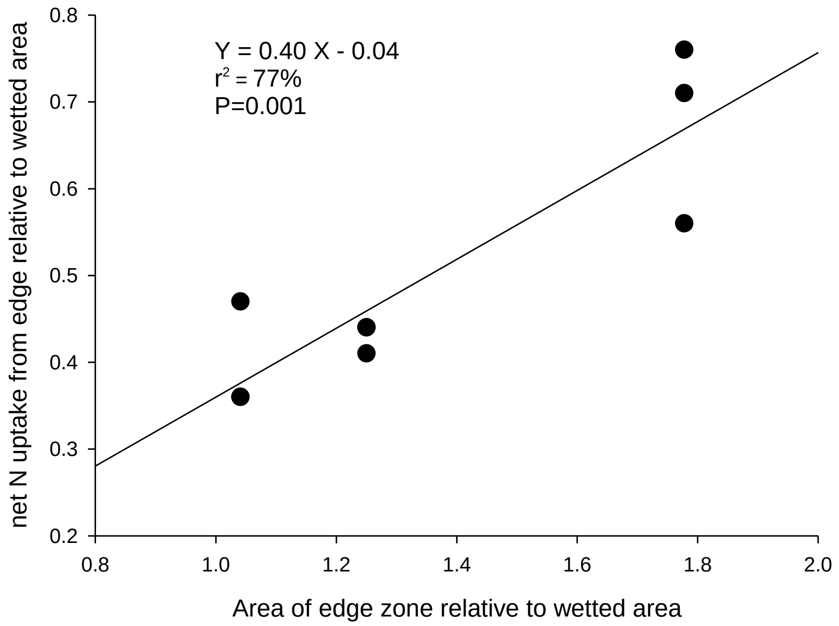

Figure 2. *Relationship between area of the edge zone and proportion of net N uptake, both expressed relative to the wetted area.*

Discussion

The results from this experiment demonstrated that 30-40% of the pasture N uptake from urine deposited on the wetted zone came from outside the wetted zone. It is not surprising that the edge contribution was larger with the smallest urine patch size (40%), because the size of that edge area is relatively greater the smaller the urine patch. The average value of 30% of the total net N uptake coming from the edge zone is less than the 40% reported by Phillips & Shepherd (2013) for a 0.36 m^2 wetted area, but is of a similar order. It is possible that the type of season may influence results.

Lysimeters have a confined edge and tend to receive urine over the whole surface area (i.e. wetted area only). These results suggest that lysimeters potentially underestimate pasture N uptake. Given that N uptake and N leaching tend to be two competing processes for urinary N (Moir et al, 2012), then this study indicates that studies using lysimeters underestimate N uptake and therefore potentially overestimate N leaching. Data from lysimeters are useful for establishing scientific principle and evaluating leaching models (e.g. Snow et al, 2011). However, when the models aim to represent a urine patch the extra N uptake should be accounted for.

Acknowledgements

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