Increasing the efficiency of phosphorus utilisation in kikuyu based pasture systems (improving the cost of production)

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Abstract (not more than 250 words)

In a pot trial kikuyu growth increased with increasing phosphorus (P) application rate up to 50% of clover P demand, with a large amount of the response occurring in the first 25%. Above 50% of clover P demand no significant response in kikuyu growth was observed.

Analysis of a field trial showed no response of kikuyu to applied P on either a sand or a loamy soil. A possible explanation is that the deep root system of mature kikuyu enabled it to scavenge P from deeper in the profile negating any P deficiency identified from soil testing in the top 10cm.

Whilst dry matter production of kikuyu was not increased in field trials by increasing the rates of P applied, the amount of P leached showed a linear increasing trend. In the poor sandy soil field trial approximately 80% of the P that was applied to annual pastures was leached below 1 metre, whilst 30% of the P applied to kikuyu pastures was leached.

These trials show that pure kikuyu pasture stands have a dramatically reduced requirement for P inputs and in a paddock situation, may require less than 50% of what is usually applied to annual systems. In essence the results of the pot trial and the lack of a measureable response in the field indicates that for most well managed grazing properties, a response to applied P in the kikuyu component of the pasture sward is unlikely.

The key question that this work leaves unanswered and that requires further investigation is: in a paddock situation, with a mixed sward of annuals and kikuyu, how much can we back off P inputs without compromising pasture production, composition and quality by inhibiting growth of the annual component of the sward?

Introduction

This project aimed to improve the cost of production for beef enterprises across the southern and western beef production zone by improving the efficiency of phosphate fertiliser use in kikuyu based pastures. This will both reduce the cost of production for beef enterprises and potentially reduce the export of phosphorus (P) from beef dominated agricultural landscapes to waterways.

Past research has clearly indicated that kikuyu based pastures can reduce water movement in the profile (White et al 2000) and reduce the leaching of nitrogen (N) (McCaskill et al 2003). More recent work however has indicated that under normal management and fertiliser regimes the movement of P has not been reduced in kikuyu systems. A proposed reason for this is that the critical soil P levels for annual legume pastures is well in excess of those required for kikuyu. The hypothesis is that at luxury P levels kikuyu is unable to take up sufficient P to make a noticeable difference in P movement, whereas better defined critical values for perennial dominated systems may allow for economic and environmental gains.

Fertilisers contribute a significant proportion of the operating costs for most beef grazing properties. It is therefore critical that fertilisers and especially phosphate based fertilisers are used in the most efficient manner possible.

The response of clover based annual pastures to P is well researched, however there is a large gap in our understanding for perennial based pasture systems. This extends to kikuyu which constitutes a large proportion of the pasture base for the southern beef herd. Without well researched response curves for kikuyu the industry is limited to the use of clover P response curves, and clover P fertiliser requirements. Preliminary work in this area is indicating that kikuyu has a lower demand for P, which poses the question as to how much P is required in a system that is at best 50% clover and usually less.

The aim of this work was to try and get a better indication of the P requirements of kikuyu based pasture systems in WA conditions. Given our knowledge of clover based pastures this project will help to improve fertiliser management and potentially reduce the fertiliser applications on kikuyu based pastures.

Materials and Methods

Pot trials

Two pot trials and two field trials were undertaken as part of this project.

The first pot trial had 6 treatments which were based on the amount of applied P required to drive clover growth on the soil in the pots. These P treatments were expressed as a percentage of that required for clover and were 0, 25%, 50%, 75%, 100% and 150% and were applied to kikuyu, rye grass and clover. All pots had basal applications of potassium, sulphur, nitrogen and trace elements. The soil used was from an area with no fertiliser history and was a very poor sand (PBI 2).

A second pot trial was carried out in 2014. This focused on slightly lower rates of P and compared kikuyu against clover. A slightly better soil was selected from an area with no fertiliser history and a P buffering index (PBI) of 28 and a Colwell P level of <2. Four replications of 6 treatments were established by adding 5, 10,15, 25, 50 and 100% of the standard P rate for clover plus basal and nitrogen (nitrogen was applied once every two weeks to the kikuyu).

Pots were sealed so no movement of nutrients away from the root zone could occur and moisture was maintained at 75% of field capacity. 5kg of soil was added to each pot giving a soil depth of 20cm.

Seeds were planted and pressed into the surface of the soil and seedlings were thinned 2 weeks after germination to base standard numbers.

Seedlings were harvested and weighed 12 weeks after seeding.

Field trials

Two field trial sites were selected that targeted a high and low P fixing site. A deep leached sand for the low P fixing site and a loamy soil for the high P fixing site with a good cover of established kikuyu. These sites were established in the high rainfall area of the south coast. One site in Hazelvale near Walpole (high P fixing) and the other is near Torbay (low P fixing).

In 2014 reduced rates deduced from the pot trials were applied to the Hazelvale site only as it was felt that the Torbay site would not be responsive.

Sites were divided into 42 plots with a randomised plot design with three replications of annual pasture and kikuyu pasture by 7 P application rates (0, 5, 10, 25, 50 and 100% standard super plus 100% Super SR) Plots were 5m x 5m at the Torbay site (where lysimeters were established) and 2.5 x 2.5m at the Hazelvale site.

Lysimeters were installed in the deep sand site in Torbay on the 0, 50, 100% P application plots and the 100% SR super plots. Water was extracted from these, filtered (<0.45µm) and analysed for soluble P concentrations (Murphy and Riley, 1962).

No lysimeters were established at the Hazelvale site due to the limited leaching that would occur on the site because of the high PBI.

Prior to annual fertiliser application to required level on these plots pre break, each plot was soil tested. After the first fertiliser application no additional fertiliser was applied to the Torbay site as testing showed that the top 10cm was still above critical concentrations, unlike the Hazelvale site.

Each site was soil sampled once a year in summer. Dry matter cuts were taken at least four times each year. The sites were all mowed after taking biomass cuts. Clippings were removed from the site to exacerbate nutrient drawdown and deficiencies.   Sites were established and monitored from June 2013 until July 2015.

Results

Pot Trial

In the kikuyu pots the growth increased with P application rates up to a maximum of 50% of clover P demand with a large amount of the response occurring in the first 25% (Fig 1). Above the 50% application no significant response in growth was observed.

Fig 1: kikuyu growth response to applied phosphorus.

The response in the rye grass pots was very different. This showed a sustained response up to 100% of the clover demand with most of the response occurring in the first 75% (Fig 2). This was the response we were expecting to see in rye grass.

Fig 2: Rye grass growth response to applied P

The response curve has a reasonable fit for the rye grass with a strong response to applied P. The kikuyu however showed a much more modest response. This occurred up to the 50% treatment after which there was no real response to applied P.

The response in the kikuyu was variable. There was a significant increase up to the 50% treatment, after this no real response could be seen. (Fig 3). Not enough clover survived in this soil type for dry matter production to be used in this analysis so clover data was not included.

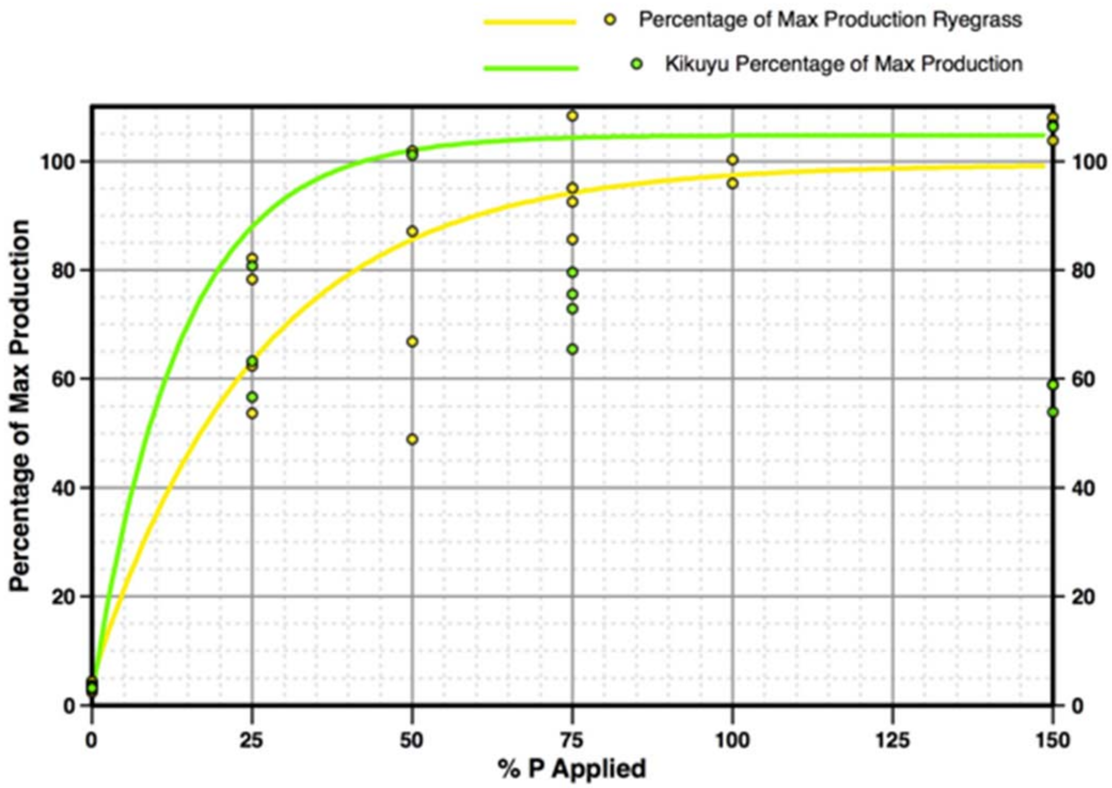

Fig 3: Preliminary kikuyu and rye grass response curves from the pot trial for applied P as a % of clover demand

The second pot trial carried out in 2014 showed a strong response to applied P from both the clover and the kikuyu (Figs. 4 and 5)

Fig 4. Clover and kikuyu growth response from applied P

Analysis of the response curves for the pot trial showed a strong response from both the kikuyu and sub clover. Interestingly the kikuyu had no significant response to applied P above 50% of the recommended clover rate (100kg/ha). The clover however showed a sustained response with a significant difference between the 50% and 100% application rate (Fig. 5).

The kikuyu had a very strong response initially and had a steeper response curve to applied P up to 50% application rate. This indicates that the kikuyu whilst responding strongly initially, has a significantly lower demand for P, when compared to subclover. This is of course based on a soil with very low background levels of P and a low PBI. It is also important to note that this is seedling response and not a mature stand in a sealed pot that restricts rooting depth to 25cm.

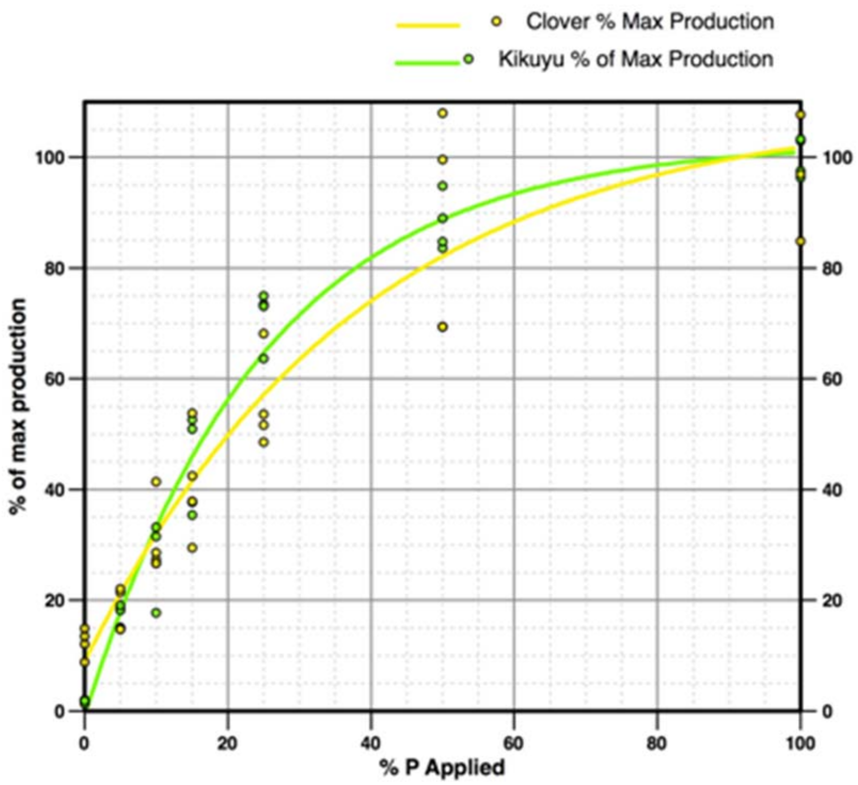

Fig 5: Kikuyu and clover P response curves.

The pot trials provided important information that led to a change in our fertiliser application rates due to the low apparent response of the kikuyu to the applied P rates (25-50% of the demand of clover).

Field Trials

Despite the Torbay site not having applied P for 15yrs, the soil P status in the top 10cm was in fact just sufficient. This was not what we were expecting and did not show up in the original testing for selection of the site which had the lowest Colwell P levels we could find on sands from extensive investigation into numerous paddocks. Given the results from the pot trial, we were not expecting a significant response to P on the site and we did not see one.

The Hazelvale site was considerably more promising. The poor fertiliser history and high PBI combined to provide a site that was moderately to highly P deficient. This was reflected in the spring 2014 cuts which showed a good response to P application in the annual pasture plots. As Figs 6 and 7 show the response in the clover plots was substantial. The kikuyu however showed no real trend, which was not unexpected for a winter growth cut from what is a summer active grass. We were expecting a more substantial response from the late spring early summer cut, which was carried out in early December.

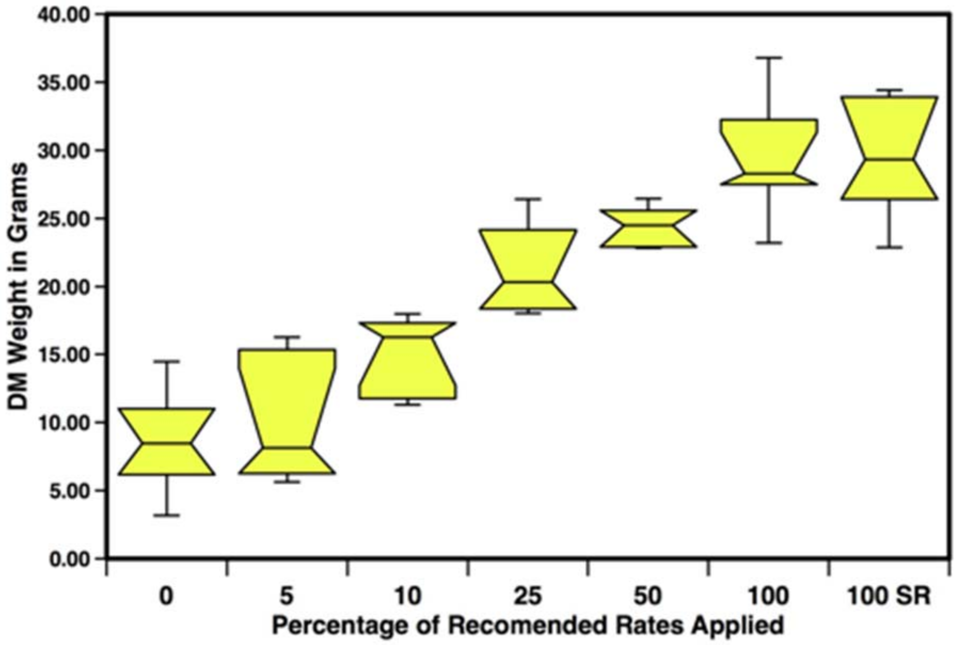

Fig 6: Box and whisker plots of clover growth (dry matter weight, grams) response to applied P as a percentage of clover demand. Whiskers extend from 5th to 95th percentiles, box spans the 25th to 75th percentile, and line across the box shows 50th percentile or median.

Fig 7: Hazelvale site showing substantial clover response. Note the lack of response in the kikuyu treatment in the foreground.

We saw no no significant response or real trend to P application in the kikuyu plots in the December cuts (Fig. 8).

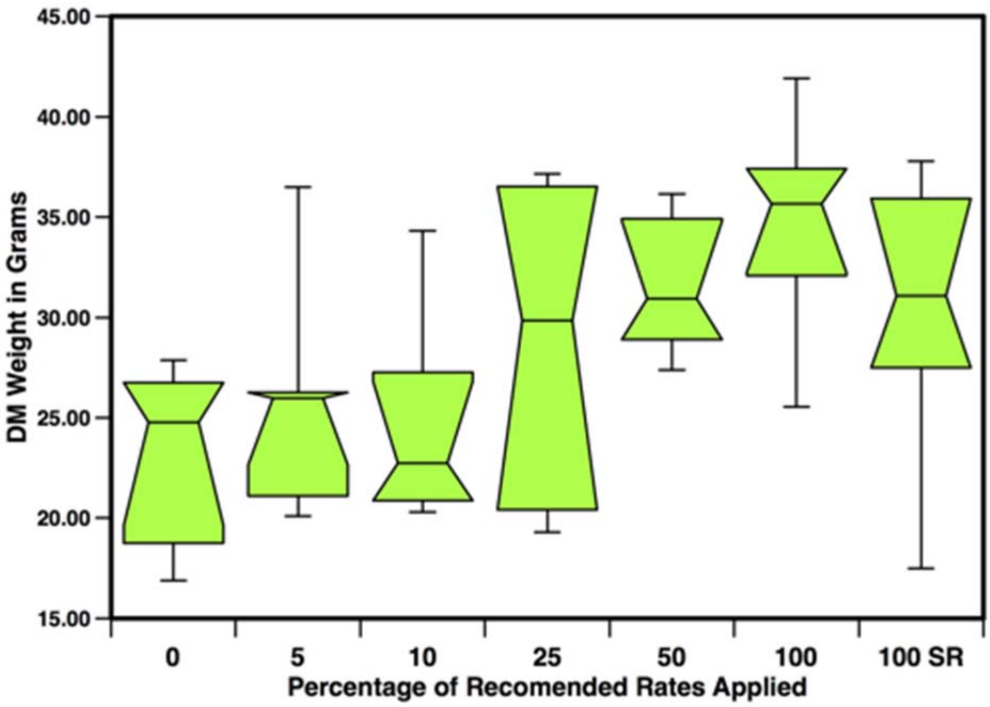

Fig 8: Box and whisker plots of kikuyu growth (dry matter weight, grams) response to applied P as a percentage of clover demand in December 2014. Whiskers extend from 5th to 95th percentiles, box spans the 25th to 75th percentile, and line across the box shows 50th percentile or median.

As we didn't get a response in December 2014 we took cuts again in June 2015 after good autumn rains again expecting that if there was going to be any response in the kikuyu, we would see it in this period. Fig. 9 shows the results from the June 2015 cuts and as can be seen again there was no response to P application seen in the field.

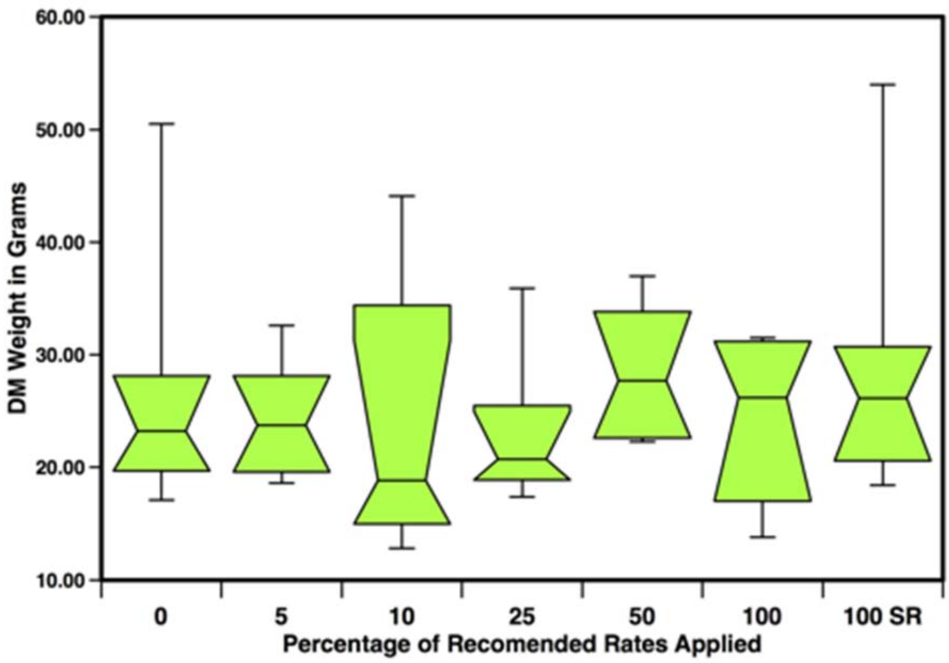

Fig 9: Box and whisker plots of kikuyu growth (dry matter weight, grams) response to applied P as a percentage of clover demand in June 2015. Whiskers extend from 5th to 95th percentiles, box spans the 25th to 75th percentile, and line across the box shows 50th percentile or median.

Leaching

Leachate was collected analysed and then converted to cumulative kg/ha of P leached. This indicated that there was an increase in the amount of P leached from the clover as opposed to the kikuyu pastures at the same rate of applied P (Fig. 10). There was also a decrease in leached phosphate from the CSBP SR super. It must be noted however that the correlation in the kikuyu is poor and variability is high.

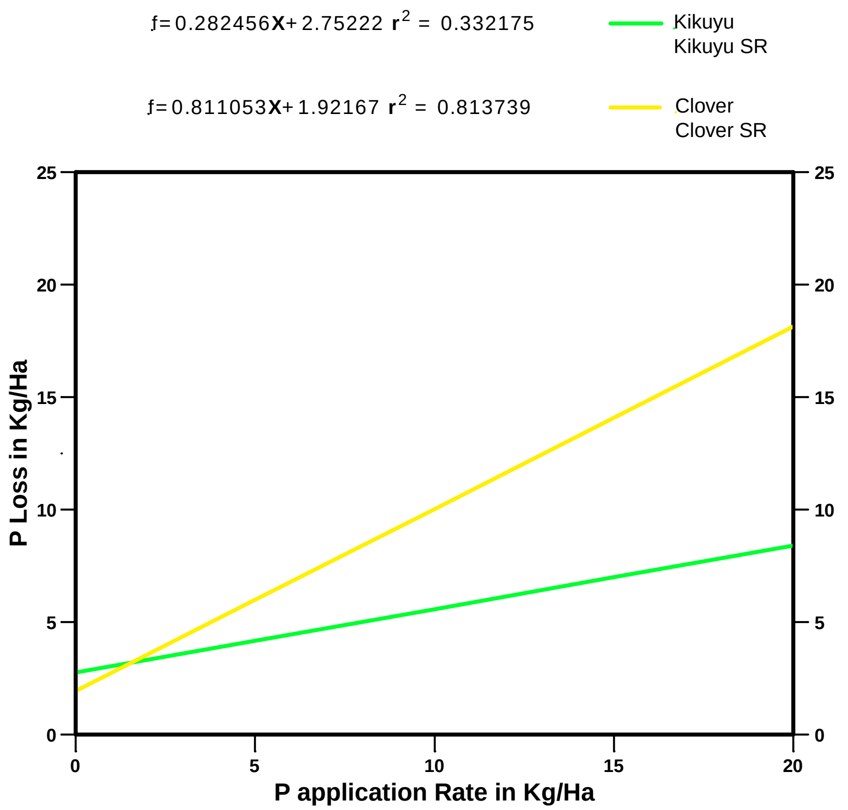

Fig 10: Leached P from clover and kikuyu plots in a low PBI site.

Discussion (this should be logical and relevant)

The pot trial has shown that kikuyu in a controlled environment appears to have a reduced requirement for P. In the pot trial kikuyu growth increased with increasing P application rate up to 50% of clover P demand, with a large amount of the response occurring in the first 25%. This highlights a reduced requirement for P compared to annual clover pastures however the kikuyu was still very responsive to P and was probably more responsive at this seedling stage in a shallow pot than we were expecting.

Analysis of the field trial results showed no response from kikuyu to applied P on either the sand or loamy sites. This was surprising given the responses to P seen in the pot trial. Even though the sites investigated were deficient in P (particularly the loamy site where we had a good response to applied P in the annual pasture) there was no response in kikuyu dry matter production to increasing P applications. A possible explanation is that the deep root system of kikuyu enabled it to scavenge P from deeper in the profile negating any P deficiency identified from soil testing in the top 10cm. These results suggest that a paddock would have to be extremely P deficient or never have had P applied (a virgin paddock) to show a response in kikuyu dry matter production from applied P.

While we did not see a response in the growth of kikuyu on the sandy soil, there was a trend to less P being leached into the environment under kikuyu compared to the annual pasture at all rates of applied P. This is the first time we have seen this in the field. Usually soil P is at such high levels that it is difficult to detect a difference in the amount of P leached from kikuyu compared to annuals. However, because this site had only marginal levels of P the kikuyu was likely scavenging P from greater depths. In this poor sandy soil approximately 80% of the P that was applied to annual pastures was leached below 1 metre, whilst 30% of the P applied to kikuyu pastures was leached.

Conclusion

This work has shown that kikuyu has a dramatically reduced requirement for P inputs in a paddock situation, and may require only 50% of the P that is required for subclover. There is large potential to reduce P inputs while still maintaining production levels on these mixed annual and kikuyu pasture swards however the key question that this work leaves unanswered and that requires further work is: in a paddock situation, with a mixed sward of annuals and kikuyu, how much can we back off P inputs without compromising pasture production and quality by inhibiting growth of the annual component of the sward?

If soil P levels are only at or slightly below where critical values should be, kikuyu pastures may offer potential reductions in the amount of P leached into the environment on sandy low PBI soils. However this may be negated once P levels are higher than what is actually required for annual pasture production, which is generally the case with 70-80% of paddocks across the high rainfall areas of WA having Colwell P levels in excess of what is required for pasture production (Weaver and Summers, 2013).

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White RE, H. K., Ridley AM, Chen D, Heng LK, Evans J, Fisher R, Hirth J R, Mele P M, Morrison G R, Cresswell HP, Paydar Z, Dunin FX, Dove H, and Simpon RJ (2000). "Soil factors affecting the sustainability and productivity of perennial and annual pastures in the high rainfall zone of south-eastern Australia." Australian Journal of Experimental Agriculture **40**: 267-283.

Benefits to the industry

Without further work current benefits are limited however this work has highlighted potential savings and production benefits that could be gained from reduced P applications and potential environmental benefits from reduced P movement off site. Further work on true paddock mixed swards would be required to identify the level and potential impact of these benefits.

Media articles and PowerPoints.

Evergreen Farming newsletter. Issue 50, March 2015, pg 14-15. Does kikuyu respond to applied phosphorous?

Poster presentation, TropAg 2015, Brisbane Qld.

Presentation at the WICC Farm Field Day, June 26 2015, Young Siding WA

Presentation at the MLA Pasture Updates, August 12, Asheep Esperance WA

Presentation at the FBG Spring field day, 16 Feb 2015, Jerramungup WA