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Section 8

Pastures

Identifying the causes of unreliable N fixation by medic based pastures

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RESEARCH

Searching for answers

Location:
Piednippie
Rainfall
Av. Annual: 300 mm
Av. GSR: 220 mm
2015 Total: 215 mm
2015 GSR: 179 mm
Paddock History
2015: Mace wheat
2014: Pasture - oats
2013: Mace wheat
Soil Type
Calcareous grey sand
Plot Size
10 m x 1.5 m x 3 reps

Location:
Pinbong
Rainfall
Av. Annual: 320 mm
Av. GSR: 225 mm
2015 Total: 286 mm
2015 GSR: 260 mm
Paddock History
2015: Medic
2014: Mace wheat
2013: Mace wheat
Soil Type
Red sandy loam
Plot Size
10 m x 1.5 m x 3 reps

Key messages

- **Nodulation and shoot dry matter in medics is depressed by poor phosphorus (P) nutrition and in-crop application of certain herbicides.**
- **Applying P when establishing a medic pasture boosts shoot and root dry matter and improves root health.**
- **The timing of application of certain herbicides can have an important effect on maximum shoot dry matter.**
- **High soil nitrogen levels can reduce nodulation in medic pastures.**

Why do the trial?

Annual medics (*Medicago spp.*) are self-regenerating pasture species that are well suited to crop rotations on neutral to alkaline soils. In southern Australia's semi-arid agricultural zones, medics provide feed for livestock, improve soil fertility through nitrogen fixation and act as a disease break for many cereal root pathogens.

Current farming systems are facing a decline in soil fertility under intensive cereal and canola cropping, and reports of lowering protein levels in wheat have become common throughout the cropping districts of southern Australia, including those where medic-based pastures are the most common.

Many medic pasture phases are now being managed to produce vigorous medic dominant pastures using a range of herbicides and pesticides to control weeds and pests. However, it appears that some of these pastures are not producing high N reserves for the following cereal crops. The broad aim of this SAGIT funded project is to assess the impact of soil nutrition, current herbicides, adjuvants and rhizobial inoculants on nitrogen (N) fixation by medics under field conditions typical of the upper Eyre Peninsula. These results should also be relevant to other low rainfall Mallee systems.

Table 1 Treatment details.

Treatment	Active ingredient	Chemical group	Application rate (units/ha)
Post-emergence			
Agritone 750	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Broadstrike	800 g/kg Flumetsulam	B	25 g + uptake oil
Ecopar	20 g/L Pyraflufen-ethyl	G	400 ml
Agritone 750	750 g/L MCPA	I	330 ml
Propyzamide 500 WP	500 g/kg Propyzamide	K	1000 ml
Verdict*	520 g/L Haloxyfop	A	75 ml + uptake oil
Clethodim	240 g/L Clethodim	A	375 ml + uptake oil
Agritone 750 - Late ^	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Chemical residues			
Intervix	33 g/L Imazamox; 15 g/L Imazapyr	B	5 ml
Logran	750 g/kg Triasulfuron	B	0.125 g
2,4-D Amine	625 g/L 2,4-D (as dimethylamine salt)	I	10 ml
Control	No inoculum, no fertiliser, no herbicide		
Nutrition	Delivered as:		
Nitrogen	Urea	100 kg	
Phosphorous	Phosphoric acid	10 kg	
Sulphur	Gypsum	100 kg	
Zinc	Zinc sulphate	2 kg	
Manganese	Manganese sulphate	3 kg	

**Verdict applied at Piednippie and Clethodim at Pinbong*
^ Late Agritone treatment applied when medic plants were 5-7 cm in diameter

How was it done?

Two replicated field trials were established in different biophysical regions of the Eyre Peninsula; one representative of typical mallee environments in SE Australia (Greg Scholz - Pinbong) on a grey highly calcareous sandy soil (Brent Cronin - Piednippie). Background rhizobia populations, soil moisture and soil fertility were determined prior to seeding. Treatments to simulate herbicide residues (Table 1) were imposed on 28 April 2015 and the trials were later sown on 13 May 2015 (Pinbong) and 14 May 2015 (Piednippie) with all nutrition treatments applied at sowing. Both trials were sown as a split plot design with the main plots being two contrasting and commercially popular medic varieties (Angel and Herald), and management options (nutrition, herbicides and inoculants) applied to both varieties. Post emergence herbicide treatments were applied after the third trifoliate leaf stage on 8 July 2015 (Pinbong) and on 30 July 2015 (Piednippie) at a water rate of 100 L/ha, with the exception of a late Agritone 750 treatment that was later imposed when medic plants were 5-7 cm in diameter (24 August 2015). Plots were kept weed free as much as possible.

Sampling at the end of September 2015 estimated medic productivity and samples will be used to estimate N_2-fixation by the ^{15}N natural abundance technique. The number of viable nodules, root health and root weight were also measured at this time. Contribution to N reserves in the soil will also be measured by sampling for mineral N in the root zone in autumn 2016.

What happened?

Cold conditions after sowing mid-May slowed establishment and early dry matter production. Whilst there were subtle differences in the performance of Herald strand medic and its mutant hybrid Angel which has tolerance to sulfonylurea herbicide residues, larger differences were measured between herbicide and nutrition treatments, hence results below are presented as the average of both varieties. Plant density was not affected at either site by the treatments imposed, including the herbicide residue simulations.

Piednippie

A growth response to phosphorous (P) and zinc (Zn) was visible during the early stages of the trial, however, when measured, only P increased shoot dry matter (DM) compared to the control, 1.3 t/ha compared with 0.52 t/ha, respectively (Figure 1). In terms of late dry matter, only Agritone 750 sprayed late reduced DM, by 40% and the effect was clearly visible in the trial. Medic nodulation scores (measured approximately 8 weeks after sowing) were lower for the Agritone 750, Ecopar + Agritone 750 and urea treatments compared to the control. No treatments increased nodulation score compared to the control (Figure 1).

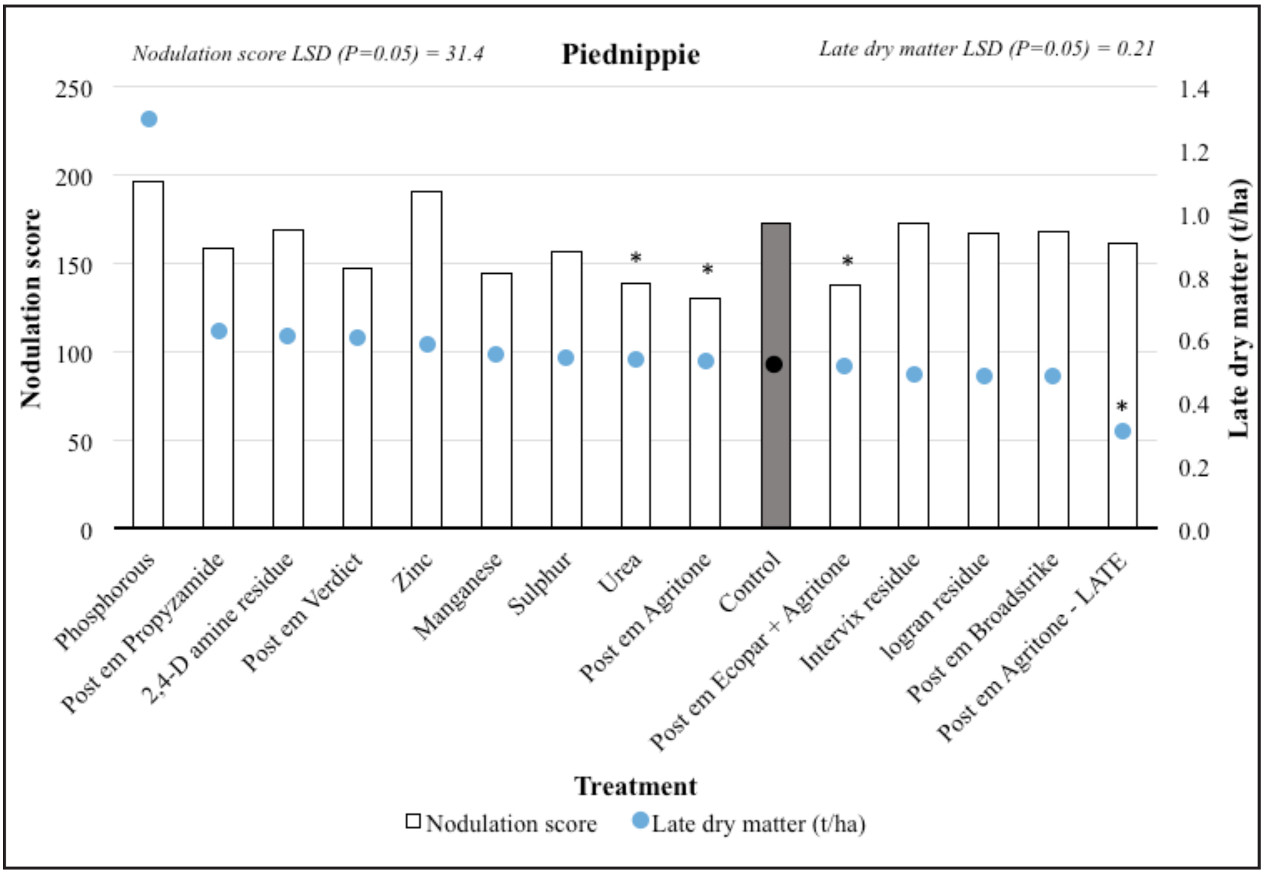

Figure 1 Nodulation scores and late dry matter (t/ha) for Piednippie 2015. *Nodulation score is a calculated value that takes account of the number, location and appearance of nodules on the root system. Higher values indicate better nodulation.*
**Significantly lower than the control (P<0.05)*

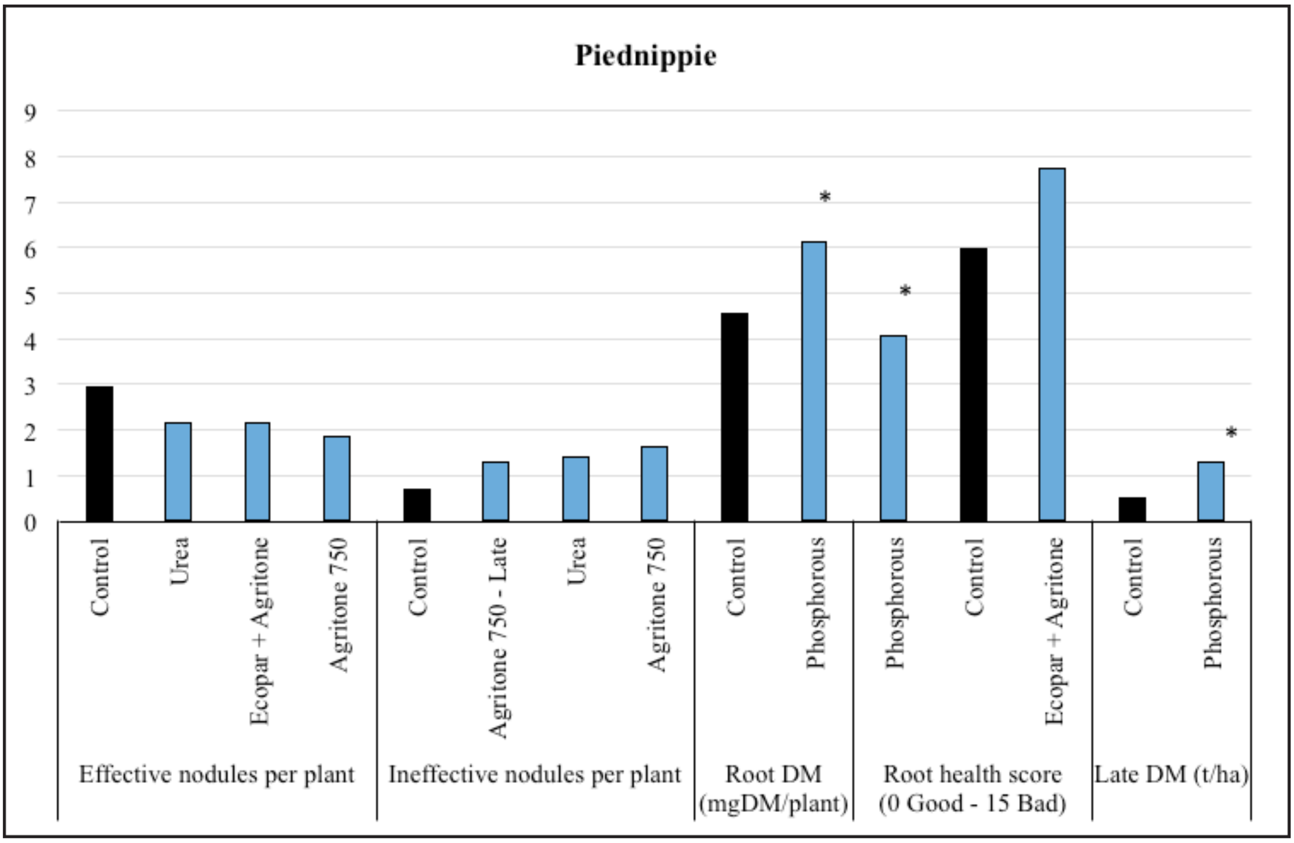

Figure 2 Treatment effects that are significantly different from the control at the Piednippie site in 2015.

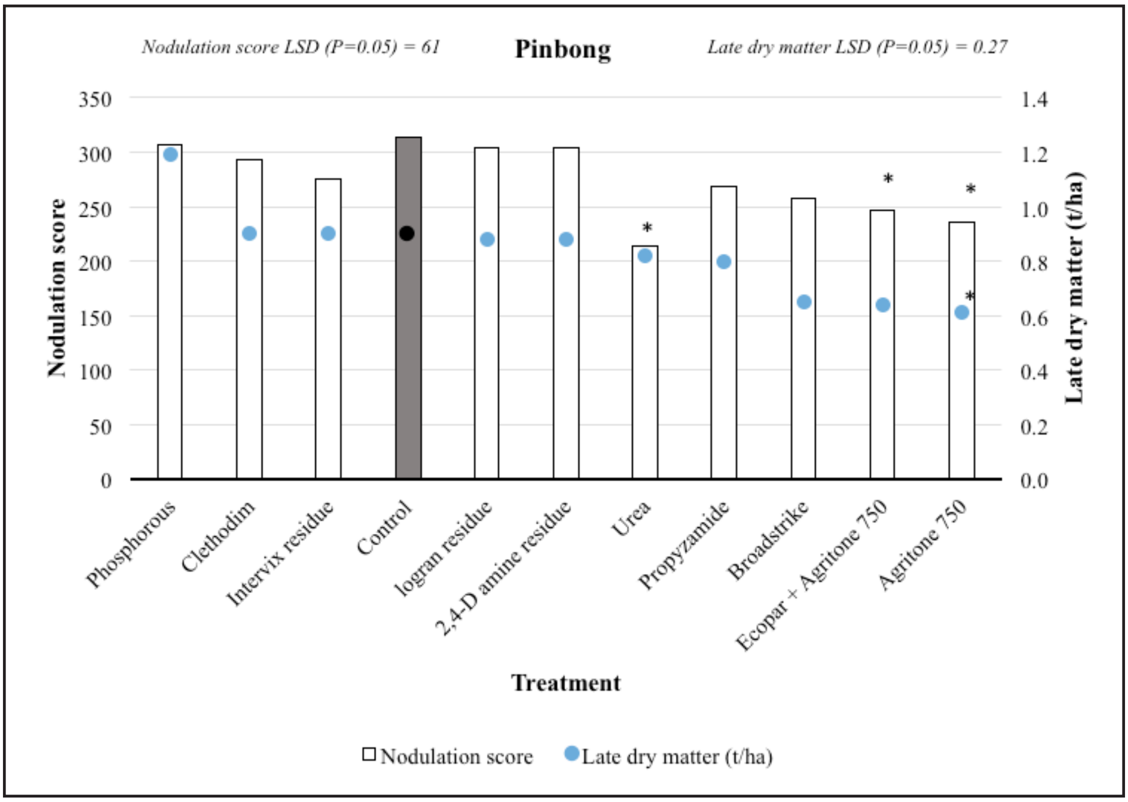

Figure 3 Nodulation scores and late dry matter (t/ha) for Pinbong 2015.
**Significantly lower than the control (P<0.05)*

Urea, Agritone 750 and Ecopar + Agritone 750 proved to be detrimental to nodulation, with lower numbers of effective nodules and higher numbers of ineffective nodules per plant (Figure 2). Phosphorous also proved to be the stand out treatment with the highest nodulation score, late DM, effective nodules per plant, root DM; and the best root health score (4.1). The Ecopar + Agritone mix had the worst root health score (7.8), which was substantially more than the control (6.0).

Pinbong

Plant populations (plants/m2) for both sites were almost the same, Pinbong (136) and Piednippie (135), however the Pinbong site germinated and established earlier than the Piednippie site because of differences in soil type. These differences ultimately affected the performance of the medics and the Pinbong site produced more herbage (0.83 t DM/ha) than Piednippie (0.58 t DM/ha). The effect of nutrition treatments on the medic was not as visually pronounced as it was at Piednippie, nonetheless, in terms of dry matter the P treatment was the only treatment substantially better than the control with 1.2 t DM/ha (Figure 3). Agritone 750 reduced late DM by 32% from the control. Nodulation scores for Agritone 750, Ecopar + Agritone 750 and urea treatments were lower than the control, however no other treatments performed consistently better than the control (Figure 3).

The number of effective nodules per plant was reduced by Broadstrike, Agritone 750, urea and Ecopar + Agritone 750 (Figure 4). These treatments, apart from Broadstrike resulted in a corresponding increase in the number of ineffective nodules, with Ecopar + Agritone 750 causing the medic to have the most number of ineffective nodules. Root DM (mg DM/plant) was decreased by urea, Broadstrike and Propyzamide, with all 3 reducing root DM/plant by about 22% compared to the control. Note that the latter two chemicals did not affect late DM on the grey calcareous sand at Piednippie.

What does this mean?

The value of legume pastures in farming systems is strongly influenced by how well they grow and fix N. High shoot DM yields mean high carrying capacity, better economic returns and potentially more N added to the system via N-rich legume residues from N fixation. On average, 20 kg N/ha is fixed for every tonne of legume shoot dry matter produced (GRDC Nitrogen fixation factsheet, 2014), therefore, a medic pasture producing 3 t/ha of DM might be expected to produce up to 60 kg N/ha in one year, which is equivalent to 140 kg/ha of urea. Variations around these average values are commonly measured. Treatments or conditions affecting nodulation, N-fixation or dry matter production can have positive or negative effects on the amount of N that is actually fixed.

P reserves (Colwell P, 0-10 cm) at Piednippie prior to sowing were 16 mg/kg and 21 mg/kg at Pinbong. Phosphorous (P) had a large and positive effect on shoot dry matter at both sites. There was a 33% and 150% increase in shoot DM at Pinbong and Piednippie respectively, resulting from the application of 10 units of fluid P/ha.

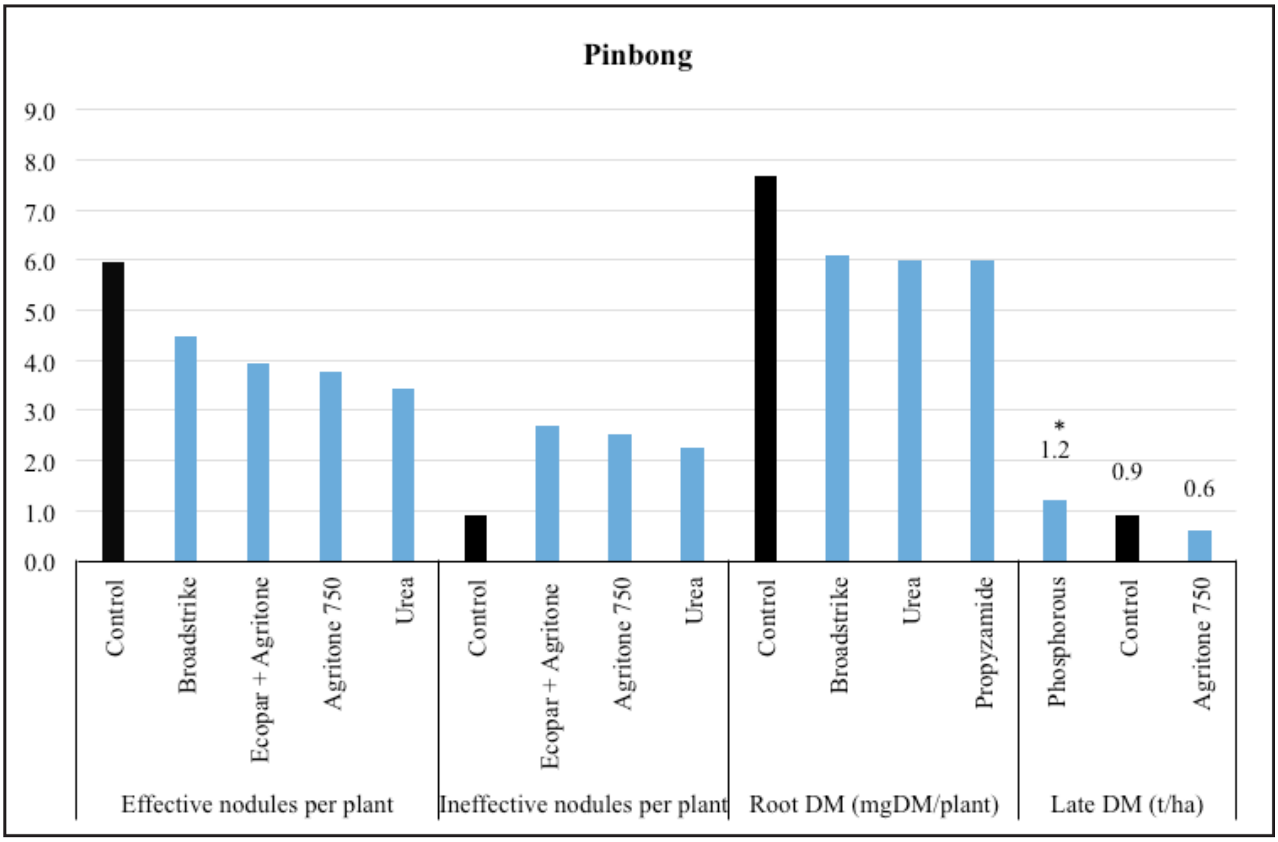

Figure 4 Treatment effects that are significantly different from the control at the Pinbong site in 2015.

If similar increases were achieved in a regenerating paddock with 3 t/ha of shoot DM, they would translate to between 20 and 90 kg/ha of extra fixed N. These amounts of fixed N are equivalent to 43 and 196 kg/ha of urea, capturing an extra $14 to $65/ha value from the pasture phase (assuming the cost of urea is $330/tonne), (Indexmundi, 2015). These gains are greater if the comparison is made to some of the herbicide affected treatments.

Our trials indicated that there can be a shoot DM penalty if certain herbicides are used as part of the weed control program during the pasture phase. There was a 32% and 40% shoot DM penalty from using Agritone 750 at Pinbong and applying it late at Piednippie. Using the same methodology applied in the previous paragraph, these production penalties translate to 19 kg and 24 kg/ha less fixed N (equivalent to 42 kg and 52 kg/ha of urea). This penalty alone could substantially reduce the value of the weed control achieved by Agritone. Measures of reduced nodulation suggest that these loss estimates will likely increase when the N-fixation data is included.

These preliminary results show that there is an advantage to be realised in terms of pasture DM through the use of phosphorous when establishing new medic pastures, even on paddocks of moderate P reserves. Chemical weed control remains a vital component of integrated weed management in cropping systems, however some chemicals may have a negative effect on pasture DM and more specifically on nodulation and N-fixation when applied during the medic pasture phase. These effects must be balanced against the value of weed control they provide. The timing of application can also have negative consequences especially when chemicals are applied late in the season. We still await the N fixation results (from the ^{15}N technique) and soil mineral N from the 2016 autumn soil sampling. These results will allow us to calculate the precise effect of each treatment on the amount of N fixed and better understand its relationship to pasture DM and nodulation under upper EP conditions.

Acknowledgements

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Registered products: see chemical trademark list.

References

GRDC (2014) *Nitrogen fixation factsheet. Southern and Western Regions. Nitrogen fixation of crop legumes: Basic principles and practical management.*

Indexmundi (2015) http://www.indexmundi.com/commodities/?commodity=urea&currency=aud. Accessed on 2/02/2016.

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