Nitrogen (N) Version 3.0 20 January 2016

Suggest friends join GrazingInfo.com for theirs & their country's benefits.

Acknowledged copying is allowed & quoting is encouraged.

The use of artificial nitrogen is a sensitive topic to write about because most farmers are set in their ways regarding what they use. Those who have plenty of healthy productive legumes like these in 'live' soils don't need artificial N, so save farmers a lot of money and work, while those who have no legumes actually need LimePlus first, followed by whatever your ryegrass Mineral Analysis shows is needed. Not just more N every time.

If you have to apply N, use sulphate of ammonia which grows more grass, and clover, than urea, costs less per kg of pasture grown, and is healthier for the soils, pastures and animals. This wonderful healthy cow is from the late Bill Chynoweth's, Pukeroro Stud of perfect pasture that has never had artificial N. Read Dairying > 'Milk Profit & Quality' for more on pasture. All those with ample clovers know that applying N will decrease the percentage of clovers and increase farm costs, and in some cases increase underground water pollution. I know of many in the Waikato who have almost no clover now so have to apply N regularly, but apply almost no lime with its synergisms (See > Minerals > Calcium) and then wonder why they are going backwards. A smart government would tax urea, which would reduce pollution and soil deterioration, and use the money to reduce the price of all LimePlus mixes applied by farmers so it costs a lot less.

Which nitrogen

Many ask me which one to use. There are now many artificial nitrogens. If any of you have done comparative cost/yield trials please send us the results. All mine and all the comparisons I know of between urea and ammonium sulphate (sulphate of ammonia) showed the latter grew more pasture for much longer and yielded more pasture, without reducing earthworm numbers, which urea does. Ammo (half urea and half SoA) has also given better results. Nitrogen needs sulphur to work, proved by ICI Fertiliser Company in the 1950s. Urea has none. Right is a paddock on a farm near Hamilton, four months after applying LimePlus. Clover increased and ryegrass improved, while weeds decreased because they become palatable so are eaten. Note how dense and even it is.

There are some liquid nitrogens, but I've not seen equal cost (including spreading cost) trials showing that any are better than sulphate of ammonia, which all my trials on an equal cost basis showed it is better than urea, but the establishment work in with the Balance fertiliser company that owns the urea factory.

Urea is made from air, so N loss from it is high. Sulphate of Ammonia is cheaper per unit of mineral and has sulphur as in urine which is an essential product for cows. In USA they feed S before calving and after, for a few months.

Urea is promoted a lot because Balance owns the factory and makes a fortune out of it, and pays commission to DairyNZ of $2m a year, and to consultants. Many comparative trials on an equal cost basis between urea and sulphate of ammonia show that SOA grows more healthy pasture for a longer time. GrazingInfo is 100% honest with no profit from sales infuence.

Read

Some may find these 32 pages on N a bit much. If so, look at the headings and read what interests you, or at the very least read the last section under, “The decision is yours.”

It takes 1.5 litres of oil, or the equivalent in gas, to make 1 kg of nitrogen in fertiliser, so using artificial N is converting oil to food! Clover based grazing is not only more sustainable from an energy point of view, but also from the soil, pasture and profit aspects.

One dairy farmer near Gordonton applied so much urea at the advice of a consultant and MAF, that his bore water became high in nitrates causing his sharemilking son first then family to become unwell, so they left the farm. The owner then also became unwell with Parkinson’s disease and died younger than normal. Read the Chapter on Parkinsons.

How much nitrogen to use?

When extra growth is going to be required it is usually best to apply N at about 40 kg of N per ha to pastures that have **no more than** 2,000 kg dry matter per ha, which is about 100 mm (4”) high in good temperate cattle pastures (as opposed to tropical pastures), or about half that height in good temperate sheep pastures, and at about six weeks before a predicted feed shortage, but not in very wet or very cold (frost) periods. There are organic products such as sheep pellets, which works extremely well in our garden where cost is not the concern that it is on farms, and where we have to apply some N because growing clovers is not practical and there is no urine and manure retuned from grazing animals. However the cost of most nitrogens won’t make it profitable on pasture when farming under New Zealand costs and low incomes.

Over-use of N for many years eliminates clovers, lowers the soil organic matter level, hardens soils and causes poor pasture as shown on this Putaruru, Waikato farm owned by three, that had 250 kg of urea per annum for a decade and no lime for 20 years. It had the worst pastures in the district. From the air it looked dreadful. The two townie owners would not apply lime or proper fertiliser, so I spread 1 kg of Fertiliser Nutrient Planner fertiliser based on a pasture analysis using Gafsa reactive phosphate (see Gardens) on one metre width at the equivalent of 1,000 kg per hectare. The farmer owner couldn’t believe it. At the first grazing two months later, there was five times more dry matter than the area that got just urea at the same cost as on the right, so two grazings paid for the correct fertiliser. The subsequent higher yields were all profit. The cows grazed the correct Fertiliser Nutrient Planner fertiliser area shorter than the urea area.

Despite this, the two townie owners and the thick Dutch farm manager would not apply the mix I recommended. What more can one do? This sort of thing makes consulting hard work and stressful.

If pastures are not growing because of dry conditions, applying N is a waste of time and money. If they are not growing because of cold, then keep reading to find the best N to use in cold conditions. If frosts are a reason for slow pasture growth, some N with sulphur and boron can be beneficial to reduce frost bight (yellow tips). N may not reduce it on its own if either one of calcium, magnesium, sulphur, boron or potassium is lacking, in which case the yellowing will occur on more of the leaf. If urine patches don’t have the yellowing, one can assume that N and/or K are lacking. If grasses are greener around clovers, especially high N producing ones like Tahora white clover shown here on the right, then low N is likely to be the cause.

If too much N is applied, plants will have a higher moisture content so a lower sugar level, and a worse freezing effect.

The above effects are more reasons why pasture leaf analyses are so important. Soil tests can’t reveal accurate N, P, K, S and other mineral requirements. New Zealand trials have shown that frost damage of clover is lessened when boron is applied to soils growing clover, apples, grapes, eucalyptus or Pinus Radiata pine trees (Monterey pine from California, originally). It stops Radiata getting “Brown top” which is what it sounds like. See Elements > Boron.

Boron slows excess moisture being taken up by plants, so reduces, but doesn’t eliminate, the "thin soup" high nitrate sappy pasture problem that causes scours.

Nitrogen is in fertile healthy soils and in the air (about 78% of the air we breathe is nitrogen as N2 gas), but most of the nitrogen in the soil is not in a form that plants can use. Plants need nitrogen in nitrate NO3 form, or ammonium NH4, or as amino acids. Legumes can use and fix N from the air, provided everything - drainage, calcium, molybdenum, cobalt in particular, and all elements and conditions are correct for maximum production.

Not much can live or grow without nitrogen. N helps the formation of chlorophyll, amino acids and protein and is in animal bodies, plants, soils, water (especially rain water - more so in electrical storms) and in air, which has about 70,000 tonnes (don’t ask me how they weigh it!) in the atmosphere above each hectare (2.47 acres), as a colourless odourless gas which we breathe with oxygen, which is about 21% by volume in air. Although there is all this N in the air, it is not available as is, most soils are low in N because plants are using it all the time, and most plants benefit from being given some from legumes and/or artificially.

High producing pastures and forage crops need large amounts of N. Growing 15,000 kg of dry matter per ha (multiply by 0.9 = 13,500 lb per acre) per annum of pasture, requires about 700 kg per ha (625 lb per acre) of N per annum. This comes from rain, earthworm casts, decomposition of organic matter and soil life (dead microbes, organisms, earthworms and insects), animal manure, lightning and legumes, all worth about $600 per ha pa. The latest high producing white clovers (Trifolium repens L) can produce about half of it. News clovers produce more than old ones. Tahora 2 produces the most.

If none of the above sources of N were available it would require 1.5 tonnes of urea per ha pa to grow 15,000 kg of DM pa. The pasture grown would not be as good (having no legumes would lower the feed and mineral content) and soils would become low in humus and sandy, drying out in dry weather. After a year the sandier soil would require even more artificial N and irrespective of how much was applied, DM and animal production would decrease, however, moderate amounts of artificial N on well fertilised and well grazed clover based pastures (about 25% clover and about 75% grasses) will not have these adverse effects.

Modern high producing grasses respond to extra N even in perfect clover based pastures on perfect soils. How much profit artificial N makes depends on its type, cost, animal returns, time of year, ability of the pasture to respond, and most importantly, how profitably the extra grass is used.

Depending on many things (rainfall, soil type, management), N is lost by animal removal from clover based pastures (about 50% by milking cows - less by other grazing systems), leaching (about 30%) and as ammonia into the air (about 10%). When about 400 kg of artificial N is applied per annum to clover based pastures, the ammonia loss and leaching double and animal removal decreases. Pugging increases N loss to the atmosphere.

Rain contains a little nitrogen (hence the rapid greening of pastures after rain), some S and some other minerals such as salt if close to the sea. However, heavy rain for weeks on end can leach and lower existing N levels in soils more than increase them, especially if the soil is sandy or becomes water-logged and anaerobic, and pasture roots are shallow. Good surface drainage with half metre deep spinner drains removing the excess rain from the surface as it falls, reduces leaching and underground water pollution.

In good soils aerated by earthworms and soil microbes under good grazed pastures containing legumes, there are reserves of organic nitrogen being made available to plants by being changed to available forms. The rate at which this happens is affected by temperature, moisture, aeration, soil properties, level of acidity and other mineral elements. 'Dead' soils (see Soils) do little of this because they are usually compact with little earthworm and microbe activity, and are quite often anaerobic, covered by thatch, moss and sometimes a skin 20 mm (0.75 inches) or more of dead inert organic matter.

Reasons for insufficient N in soils

- Poor drainage.
- Anaerobic, dead, tight, compact soils.
- N leaching out of low-humus and sandy soils.
- Harvesting (rather than grazing crops and pastures) which lowers soil humus.
- Over-grazing which pulls up clover stolons. Once clover levels in a pasture get below 20% this occurs more because ruminants like clovers.
- Low calcium, boron, cobalt, sulphur, molybdenum, K (rare in NZ now), high K (common now) and low salt levels.
- Low humus levels in soils.
- Dr Lewis Schipper ETS didn't know why the average Waikato flat land organic matter is decreasing, but not in hills. It is the use of urea by dairy farmers.

Optimum P and K are also needed, but are seldom lacking because of the promotion of N-P-K fertilisers.

1. Not enough balanced fertilisers applied.
2. Poor pasture management such as pugging and allowing camping areas.
3. Insufficient earthworms, or inactive ones. (See Soils > Earthworms)
4. Insufficient legumes, or old low-N producing ones.
5. Temperature too low. Generally little nitrogen is fixed at soil temperatures below 7º C.
6. Compact soils inhibit biological processes from occurring due to lack of oxygen.
7. The manufacturing of nitrogen by clovers is relative to many things, but mostly to the clover's own requirement for N, so, if artificial N is applied, the clover promptly makes less, at the expense of the grasses around it, so what happens eventually where artificial N is used repeatedly at high rates, is clovers disappear and grasses take over. Small regular applications with controlled grazing to prevent shading clovers doesn't adversely affect clovers to the same degree, but still does reduce the amount of N they produce.
8. Low-N producing clover varieties. Alsike clover and birdsfoot Trefoil don't make much N, but tolerate cold wet conditions. Tahora, a small leafed prostrate white clover makes twice as much N as the old NZ white clover cultivars such as Huia which is in most New Zealand hill pastures. Kopu was a dead loss, lasting only a few years because of one short lived parent. Never sow it. Sow Apex and Weka always with Tahora 2. It sells out, so don't believe the sales person saying it is old and superseded.
9. The correct rhizobium is not present because clovers were not inoculated, or not inoculated correctly because a wrong or expired inoculant was used, and/or sun or heat killed the inoculant before or after inoculating the seed. Clovers then have nodules that are white so contain no N. They should be pink or brown inside. A white nodule also indicates low molybdenum in soils.
10. Insufficient Ca, P, K, S, Na, cobalt, copper, boron, molybdenum and/or elements we don't even know about. This statement is based on the fact that after deep chisel ploughing, over trenches and next to gravel roads, legumes frequently grow much better, possibly because of elements in the subsoil. Marine reactive phosphate (RP) also grows more clover than superphosphate (Winchmore Research, NZ, trials) and many on farm comparisons and observations, provided rainfall exceeds 800 mm (30 inches). Also pH must not be too much above 6 and the soil must not be dead. RP's don't grow much pasture in dead soils, even if it is acid which makes the RP available.
11. Overgrazing which pulls up white clover stolons (surface runners) so that the mother plant doesn't spread. Check white clovers when stolons are spreading (some by a metre a year if not

over-grazed) and you'll see that 90% of the clover nodules are on the stolons, not on the mother plant. In Prince Edward Island, Canada, after winter snow and freezing, I noticed that the only surviving white clovers were the stolons, not the mother plants which had been heaved out.

12. Cold temperature and low sunshine.

13. Prolonged and/or excessive artificial N use which uses up soil organic matter, so can create low humus soils. Depending on soil and other factors, 300 kg N per ha pa can do this under grazing where animal manure is also returned to pasture. Lower amounts can do it when harvesting pasture. Clover N fixation usually decreases by 50% of the amount of artificial N applied. This increases the effective cost of applied N by more than 50%, because the clover leaf percentage also decreases which lowers the feed value of pasture and the animal production.

14. As soils and pastures improve under controlled grazing the percentage of grass increases resulting in fewer clovers to make N.

15. Low Mo (under 0.5 in mixed pasture leaf) reduces clover nodulation and nitrogen fixation. Many farmers and some AgResearch staff rush to apply N without checking molybdenum levels in pasture leaf. Liming could increase Mo levels and give other benefits to increase pasture production over a longer term than applying N.

16. And, mainly, too much urea for too long.

How legumes supply N

If the correct rhizobium is present, legumes absorb N from the air and store it in their nodules and in the whole plant (legumes contain high levels of N protein), then incorporate N in the soil when some of their roots and leaves die, which benefits the growth of the legume concerned and the adjacent non-legume plants.

Nitrogen fixation by legumes is the cheapest, best and most sustainable form of N. Fixation varies from 0 to 400 kg N per ha per annum depending on many things. Briefly, the wide variation (0 to 400) is because of variations in-

- Species of legume — white clovers produce more than red.
- Cultivar of species - Grasslands Tahora white clover produces much more N than Kopu 2 and Kopu 2 produces more than Huia.
- Strains of rhizobium. New ones produce more than old ones, but in an established pasture it is impossible to change them. When sowing pasture after extended cropping, inoculated seed should be used.
- Soil types.
- Soil fertility affects the amount legumes produce.
- Soil condition. Clovers in compact tight soils produce less.
- Moisture levels.
- Mineral deficiencies.
- Length of grasses. Tall grass shades clovers which need a lot of sunshine, that is why they have a flat leave facing upwards.
- Type of companion grasses. Clovers have difficulty thriving in Kikuyu, Bermuda and similar dense runner type grasses, but do so under good management of keeping grasses short.
- Climate. Less is produced in low sunshine areas well away from the equator, especially during short days in winter. Ample sunshine is needed.
- Time of year. Less is produced in cloudy and cold winter weather, and in mid summer dry, hot weather.
- Severity of grazing. Less is produced after over-grazing pulls up runners.
- Amount of artificial N used. The more artificial N used the less N fixed.

Causes of inoculation failures

- The rhizobium used may have been dead because old or high storage temperatures killing it.
- Farm inoculated seeds may have been exposed to sunshine. Commercially inoculated legumes must and usually do have a coating to protect the inoculant.

Maintaining clovers in pastures

When the percentage of clover in pastures decreases, animal production per kg of pasture dry matter decreases. A major disadvantage of less clover in pastures is the lower feed value and lower animal consumption of grass-only pastures by cattle and sheep, but not by goats which prefer grasses.

White clover stolons spread and become new plants and the mother plants die, especially if heaved out by frost. Stolons make much more N than the mother plant. Check the nodules on both and you'll be amazed at how much more the stolons make.

Red clovers seldom last for many years unless self seeding occurs, but even white clover plants don't last forever, but need not be resown provided -

- Clover stolons are not pulled up by over-grazing.
- Clovers are allowed to self seed. It is hard to stop some white clovers flowering and seeding even when grazed fortnightly.
- Bees are present to pollinate them.
- They are not shaded out by grasses.
- Drainage is adequate.
- Pastures are adequately fed with Ca, P, K, S, Mg, B, Mo, Cu, and Co. Intensive pasture production even under grazing, lowers the soil's reserves of all elements. This happens more quickly in soils which were initially a little low.

The high clover pastures usually have about 4.5% N which is 28% crude protein (CP). New Zealand dairy cows have been developed over generations on high protein pastures and can cope with them to a degree, but don't do so as well as when it is a bit lower. When CP is high, bypass protein is of no benefit. When dairy farmers go sheep farming and use the same high rates of fertiliser, sheep can scour severely on the fast growing, high nitrate pastures. Also, young cattle suffer more quickly from high nitrates than older ones. See Animal Health > Nitrates for full information.

At this point it may be worth describing the word "farming". It is not "mining", but sometimes it is if animal products are sold off the farm and all elements removed are not put back, or if animal products are sold off and only N, or only the main elements, are returned. In my opinion, farming is improving the farm, not just sustaining it, and at the same time, producing top quality food and/or products, and making a profit.

If the newer better clover varieties are available they should be sown. Current white clovers produce about twice as much DM and N as ones developed 60 years ago, such as the old New Zealand white clovers, and Huia bred 50 years ago, and even Pitau, bred about 30 years ago.

Obviously, where farmers don't have legumes in their pastures they will use artificial N, but the slogan from Sharon Harris, clover researcher at Dairy Research Corporation, Ruakura, NZ, in the 1990s should be remembered, "Nitrogen for pasture quantity, but clover for pasture quality".

She also reported at their April 1995 field day -

- Cows produce much more milk on clover based pastures.
- 200 kg of artificial N per ha pa reduces clover N fixation from about 280 to about 150 kg per ha per annum.
- 400 kg of artificial N per ha pa reduces clover N fixation from 280 to about 40 kg per ha pa.
- When using artificial N, grasses should not be allowed to suppress clovers.
- Applying no more than 40 kg of N per ha at any one time is best.

The above relates to the Waikato. Figures will vary around the world. In Holland they'll use more, and in Switzerland they are not allowed to use as much.

When calculating values of extra pasture grown from using N, remember to allow for the decrease in feed value (ME) through having less clover in the pasture, a lower mineral content, the value of other fertiliser required to grow pasture and the reduction in humus which artificial N causes.

If applying N grows, say, 1,000 kg per ha more pasture dry matter containing 0.5% phosphorus, worth $2 per kg, then the 5 kg (0.5% of 1,000 kg) is a loss of NZ$7.50 per ha. Also add the value of other elements lost from the extra 1,000 kg per ha of pasture. If grazed, some will be returned to the pasture. So when calculating the extra pasture grown from artificial N, allow for this.

Artificial N

The scouring often seen in cows in spring, and autumn after rain, is often accentuated by artificial N and insufficient selenium. See Elements > Selenium, and Beef > Profit from Beef. Scouring and looseness of bowels means that food is not properly digested. High N accentuates this.

Nitrogen is the controversial fertiliser on pastures, and has been so in New Zealand to my knowledge since 1958 when I used Sulphate of Ammonia, also called Ammonium Sulphate (22 N and 24 S), at 120 kg per ha on newly sown pastures a few times to help establish them on raw peat, and was told by two ex Ruakura technician members in our discussion group, "In New Zealand we don't use nitrogen on pasture". My South African accent told them that I was one of the many who came to wonderful New Zealand in the 1950s. This New Zealand attitude to N use has now reversed to over-use of it.

I hope that all farmers everywhere apply sulphate of ammonia, not urea, to newly sown pastures as and when they need it, which should be about five weeks after sowing and until clovers produce sufficient N. Don't apply any at sowing, because cultivation and rain provide enough until the grass is growing, and if too much is applied, especially when sowing winter ryegrasses on their own or in a mix, nitrate toxicity can adversely affect animals. Make sure that N is applied before grasses show signs of needing it, especially if tall fescues are grown because they are slow to establish and need all the help they can get. N starved grass seedlings can die without you noticing it.

The six week intervals between applications are not exact dates. Sulphate of ammonia (SoA) lasts longer than urea. Also, it depends on the pastures sown, for example fescues need more than perennial ryegrass to help quick establishment.

New pasture on poor soils (low in N) and most soils after harvested maize crops (which remove a lot of N), might need N sooner and more frequently, and for longer. Fertile soils which previously had a grazed crop will need less because of the animal manure returned. Autumn sowings after good clover based pasture (grass to grass with no crop in between) should need none until early spring. Applying it before needed can increase the chances of the dangerous nitrate toxicity.

Aim to apply each dressing of N just before the pasture starts to yellow, not after. Once seedlings go yellow, some die, especially if sown too thickly.

N is handy for overcoming unusual pasture shortages caused by bad weather. It provides extra feed when short, but is not cheaper than buying low cost silage, but is cheaper than buying normal hay or grain. If it is being used routinely at high rates to grow grass, then it won't be of much use to obtain EXTRA growth.

Applying it in autumn before cold weather to increase pasture reserves for winter and in early spring and in summer before dry weather starts, can be worthwhile - provided all pasture grown is consumed.

There are times when applying N to even the very best clover rich pastures will grow more grass (note: grass, not pasture). However, applying 40 kg per ha of urea reduces N production by clovers slightly and halves earthworm numbers (I have monitored this on many farms), but depending on all conditions, it will increase the grass grown in subsequent months. Sulphate of Amonia has sulphur which clovers need so grow more, and increases the N effect of grasses because N and S are synergistic. If frequent applications of urea continue, soil and pasture degeneration will continue.

The cost of applying artificial N is not always matched by increased profit. Sometimes it gives more silage which is a further cost to make and feed.

Use and enter your costs in the spreadsheet called Pasture Fertiliser Lime Trials to measure and record the exact figures for the months that differences occur.

Also see Pasture Silage Hay Crop N Costs, especially the true cost of applying N.

True cost of artificial nitrogen

As with most research, the costings of using artificial N that I've seen have not included the hidden costs, such as the cost of the extra Ca, P and other elements used by producing more grass and animal products which leave the farm. It has been shown world-wide that applying N uses up humus, so the typical one or two year N trial cannot give conclusive figures. Many Northern Hemisphere farmers are laughing at NZ ones increasing N use while they are reducing it. Their researchers claim that quantities of N already undergound, without more will cause pollution for decades.

Nitrogen should be a back stop for late autumns and springs and before lean periods such as before winter and before summer, not as part of the pasture growing programme. Examples are two Waikato clients not using N or bought feed. One produced 520 kg of MS per cow and 1,050 per ha on sandy loam, and the other 930 kg per ha on deep peat. Both made good profits and had plenty of feed during lean springs. Both used maize green-feed and maize silage and put their money into optimum lime and P, not N, and did much better than most.

Both changed to growing and grazing lower cost summer forage crops of Pasja and Nutrifeed costing about 33 cents per kg of dry matter fed, as apposed to 47 cents for maize silage fed.

In mid October, both had grass ready for silage. The “more stock at all costs” brigade will say that they were understocked. My computer programme shows they are correctly stocked for maximum profit - after allowing for the cost of keeping and milking extra cows.

The use of urea as a fertiliser by some is getting out of hand. Many of the farms wouldn’t need it if enough Ca, P and sometimes deficient trace elements were applied. The more urea used, the more Ca, Mg, P and other elements needed. Few farmers allow for this.

In most cases, applying Ca, Serpentine and the deficient trace elements grows more and much better pasture than applying plain N.

Before applying N

- Make sure that drainage, Ca, P, K, S and other levels are correct based on pasture analyses because having all at optimum grows more and lower cost pasture than applying N, and also gets more out of any applied N.
- If pasture S levels are low (below 30%) using a fertiliser containing S such as Sulphate of Ammonia will be an advantage and give better results per dollar than nitrogen without S.
- Remember that artificial N is like a bad drug - start using it repeatedly on clover based pastures and it is hard to stop, but like a medical drug it has a place - when a feed budget (See Spreadsheets > Feed Budget) shows a pasture shortage ahead.
- Ensure that the soil temperature is adequate for growth and that there is sufficient moisture and for grass growth, or that rain is imminent.
- If pasture copper levels are low (below 10 mg/kg for cattle and below 8 for sheep), or animal blood copper levels are low (see the Blood and Liver spreadsheet), and pasture S levels are high, don’t use a nitrogen fertiliser which has S such as Sulphate of Ammonia and avoid superphosphate with its 11% S.
- Excess protein can lead to high blood urea levels and low conception rates. Applying urea increases these problems, and can increase the urea levels in milk, which many overseas countries measure in milk daily. New Zealand doesn’t have a problem so doesn’t measure milk urea.

Usage

The use of N on pastures has increased in NZ in recent years, mainly because -

- It has been promoted more, while lime has not.
- It usually is easier and quicker to increase pasture growth than to grow maize for silage, or buy hay or other supplements, but provided the extra pasture grown is all used.
- Increased stock numbers per ha have increased the number of times when feed shortages occur, so more N is used to alleviate these.
- The requirement to increase profitability, especially on smaller farms, by using N to allow more stock to be carried.
- As the values of land and animal products increase the financial return from artificial N increases.
- Farmers can see the results in a greener colour within a month of applying it, and see the extra pasture soon after, so feel rewarded.
- When calcium is lacking, the same greening and extra growth occurs after applying it, with Mg if necessary, and it lasts longer and does more overall good. See Elements > Calcium.

The decision to use N is often made fairly hastily, after it is obvious that a shortage of pasture will occur, but in this situation maximum growth is not achieved from the application of N. It is far better to measure and predict future pasture growth by feed budgeting, than to decide to use N after the feed shortage has occurred. The old sayings “grass grows grass” and “a stitch in time” apply when trying to get the maximum benefit from artificial N.

Applying N to paddocks which have been grazed down to 1,000 kg DM per ha (one to two inches) or less, will result in loss into air (volatilisation) especially if no rain falls or leaching if prolonged heavy rain follows before the grass has had time to take it up and turn it into growth. Applying it to pasture with about 1,600 kg DM (three to four inches) will lose only half as much and give much better results, but, if the decision to use N has been left too late, there may not be many paddocks with this amount of cover. Grass growing fast at the time of application will use more of it before leaching losses occur.

Small frequent applications give better long term results than larger amounts less often. It is far better to apply more to newer pastures (ones sown in recent years) which will give a better return than old worn out pastures which can give little response. About 40 kg of N per ha can double growth and is the maximum suggested per application. In New Zealand 150 kg per ha of nitrogen pa is the maximum recommended from effluent and/or artificially.

When soil temperature is about 5 degrees C, each kg of N in urea will produce only about 5 kg per ha DM. At 10 degrees C about 15 kg per ha DM can be expected, however at these low temperatures Sulphate of Ammonia will provide more N than urea.

Urea is the most popular form of N in New Zealand because it is promoted most by the NZ manufacturer, costs less per kg of N and is more concentrated (45%) than others so less is needed to transported and spread. A previous advantage was that it is granulated for easier spreading, but Sulphate of Ammonia, Ammo and others are now also granulated.

After wet periods sulphur (S) is likely to be leached, so can be lacking. If enough elemental S has been applied in autumn, levels can be better, but still low because the cold wet conditions will slow its being made available. If S is low, definitely use Ammo (22 N and 12 S) because N must have sulphur to work. Ammo will also give a longer response than urea and if S is low and soils are cold it will be faster than urea. Sulphur coated urea is available in some countries.

Some farmers have noticed that SoA makes mature legumes grow faster. This can happen when legumes are not making N or when S is low.

When to apply N

Apply it when deficiency symptoms start to show and before extra pasture is needed.

On average soils in normal weather, the following figures show that it is better to apply N in late autumn or in very early spring rather than in mid winter. So planning, feed budgeting and doing things on time pays.

The costs above include other growing costs of (22 cents per kg DM) and grazing (only one cent per kg DM) costs which have to be included when calculating the true costs. The land cost is based on land worth NZ$35,000 per hectare (US$7,800 per acre). This has to be done to compare N with buying feed.

See the spreadsheet Pasture Silage Hay Crop N Costs to calculate your exact figures.

SoA or Ammo (30% N, 14% S and $571per 1,000 kg) will grow more pasture, especially in the cold months than urea.

On poor and colder soils, the above responses will be lower, but in warmer areas responses will be higher.

Obviously, where farmers don’t have legumes in their pastures they will use artificial N, but Sharon Harris’s slogan (above) should be remembered.

When N is applied and the animal stocking rate is too low, pastures can grow to 3,200 kg DM per ha which is too long and is wasteful. Clover loss can then be double that of pastures not allowed to exceed 2,800 kg under good grazing, except for once a year harvesting when pasture can get longer for a week or two.

If bloat is a problem, N can be used to decrease clover and increase grasses, but high nitrate grasses (caused by high amounts of growth elements - N, P and K) even without clover can also cause bloat as well as nitrate toxicity.

With the increase in Clover Root weevil and Clover Flea in some parts of NZ there could be an increase in artificial N use, however, as with Argentine Stem weevil and Army worm, a solution is likely to found. Clover Root weevil has been in Europe and USA for ages and hasn’t eliminated their clovers, even in similar mild Mediterranean type climates, but they may not have had as many larvae at 200 per square metre in soils and weevils at 1,000 per m2 in pastures, like some have had here.

Meanwhile, farming to encourage clovers to yield more is advisable. This means growing the best clover for the soil, the climate, the grazing management with adequate drainage, lime, fertilisers and trace elements required, and controlled grazing.

Fescues allow more clovers to grow with them than do high endophyte perennial ryegrasses. Some high endophyte perennial ryegrasses are worse in this respect than others. Good fast growing fescues with clovers still need artificial N to get the best out of them. N applied to fescues in autumn and in late spring for summer growth can be rewarding.

N applied to even good clover based pastures a month before summer dry periods gives a good return and grows cheaper summer dry matter than crops, unless the crops are grown on run out pastures and are high yielding. The artificial N in early summer helps grow more leaf, rather than have ryegrasses shoot to seed.

Apply N to paddocks that have 3 to 4 days growth rather than freshly grazed ones.

Urea should not be applied before heavy rain because a lot of N can be washed off and leached down, especially if the soil is already wet, and shallow like N fed soils lacking LimePlus are.

The nitrogen in urea has to be converted to ammonia, some of which can be lost in hot windy conditions if there is not enough rain to wash it in. It is then converted to nitrates which is available to the plant roots to take up after about 5 days. The nitrate levels in plants peak at about 10 to18 days, after which levels decrease.

Don't apply N -

- To pastures of Velvet Grass, Brown Top, Bent Grass, Sweet Vernal, or low fertility slow growing grasses which don't respond very well to N.
- In mid winter (see figures above) when pasture growth is very slow. In warm areas where growth in winter is reasonable, this will not apply. Alsike clover and birdsfoot Trefoil don't make much N, but tolerate it.
- In spring because it can then swamp and lower clover levels, create surpluses which make pastures less palatable if too long and may have to be harvested which is a cost, unless required for winter feed. Also, long pasture and those without legumes have a lower feed value, are less palatable and less productive. If for harvesting this may not apply.
- After dry periods, because N builds up in the soil when it is dry and not growing pasture. Artificial N will accentuate nitrate toxicity which kills many animals every autumn - even without added N.
- To pastures to be grazed within three weeks of applying artificial N.
- In cold, wet conditions which slow pasture growth and reduce the speed with which N is taken up by plants, so little growth is achieved, but leaching is high.
- One should not expect pasture growth from plants that are not growing when biological activity in the soil is unlikely to be occurring because of cold or heat and drought. Given that one should not apply artificial N if the plant is not growing then in practice the situation described should not arise. Soil biological activity stops at about 5 degrees C so N and fertiliser applications are not likely to achieve pasture growth then.
- If the extra pasture won't be needed.
- If soil is waterlogged.
- If no rain is due.

The financial returns from using N can be very disappointing when -

- Rain doesn't fall within a day or two, especially with urea which loses more into the air than SoA or Ammo.
- Soil mineral levels and humus, all of which make up fertility, are low.
- Soils are water logged.
- Sulphur is lacking, unless S is also applied at the time. Some N fertilisers have S.
- Stocking rates are not high enough to use the extra grass grown, or it is not harvested.
- Grasses are allowed to swamp out the legumes.
- High rainfall occurs on soils which are sandy and/or have low humus levels, so substantial leaching occurs - irrespective of the type of N used.
- Keeping grass short after N is applied increases vitalisation and prevents high pasture yields.
- Low soil fertility and a lack of clovers resulting in a slump in growth a few months later.

- The lack of clover in N fertilised pasture lowers the important mineral levels and feed value of pasture, increasing the incidence of metabolic diseases and endophyte toxicity (perennial ryegrass staggers).
- Extremely cold frosty weather in winter is giving slow pasture growth of about 5 kg DM per ha per day, because if N doubles growth to 10 kg, the cost of the extra grass grown is higher, so the profitable return is less than if applied earlier in autumn and stock piled, or applied later in early spring, and a growth of 20 kg per per day is doubled. Also grass grows grass. The lesson from all this is to plan ahead and time N applications to grow pasture ahead of requirements, rather than after most pasture has been consumed.
- The same amount of money spent on improving pasture species and soil fertility with phosphate can frequently give a better long term return than N.

Artificial N can cost farmers

Sir Bruce Levy in his Grasslands of New Zealand (1951 updated in 1970) explained that -

"N fertiliser had been a subject of debate ever since artificial fertilising of pastures began in the late 1920s.

"Field grazing trials over a wide range of soils and pastures in NZ using phosphate and N "proved a real setback for artificial N in that, although there was an initial response from the SoA used, the after effects of loss of clover, dry unthrifty harshness in the sward, went against the adoption of N use, except on ryegrass dominant pastures on soils which were wettish, with correct levels of humus and calcium". (NB. These trials were on poor pastures and at low stocking rates.)

"Good pastures on correctly fertilised calcium and phosphate, fertile soils can respond well to N.

"Turf research over 25 years showed that the continued use of N decrease organic matter, adversely affected vegetation, soil organisms and soil structure. Clovers were eliminated, earthworm and bacterial life ceased, tough low producing matted turfs resulted and the soil formed a hard pan almost impermeable to water. If not carried too far, for playing fields and airstrips this was ideal, but for pastures it was the reverse."

End of quote.

All the effects of using too much N at more than 100 kg N (especially urea because it has no sulphur) per ha per annum for too many years have yet to show all the bad effects on some pasture farms. When they do, there will be many sad farmers.

1. The first negative effect is a decrease in the number of earthworms. Twenty earthworms per spade spit of 20 x 20 x 20 cm (8 x 8 x 8") equals 5 million per hectare which move 30 tonnes of soil a year, produce up to 90 kg N per ha per year. Increasing from almost none to this number can double pasture growth.
2. The second effect is a decrease in the soil's organic matter (humus) content, followed by a reduction in soil microbes. Both earthworms and soil microbes need humus to thrive. I've seen soils under pastures at Groningen university farm in Holland after decades of high N fertilising that had turned into a sandy, almost concrete, that my spade could hardly dig through. See Holland below.
3. The third effect is a decrease in the clover content of pastures, which means that the amount of calcium, magnesium, boron and cobalt that the grazing animals get will decrease, because clovers have much more of these elements than grasses. This can lead to an increase in grass staggers and milk fever and general ill-thrift followed by lower production.
4. The fourth effect will be an increase in the percentage of perennial ryegrass in the pasture, at the expense of all other species. This will lead to a chronic shortage of feed in summer dry periods. In the initial stages of N use, applying it in early summer will increase summer growth, and overall pasture cover then - provided it rains. However, after a number of years of using excess N, the percentage of humus in the soil will decrease, after which the early summer applications of N will not help as much, unless we get spring rainfall quantities in summer, when the N results would not be required anyway.
5. The fifth problem is that perennial ryegrass pulling increases because roots become shallower.
6. The sixth is water pollution. Some say it is not a problem, however, why did -
    a. Nitrates increase in the bore water of a very high N use farm in the Waikato? Some local bodies or councils have now set N application limits.

b. A province in Switzerland banned its use?
c. Holland set limits?
d. Some provinces in countries as large as Canada set limits (see below).

7. The seventh is that elements such as cobalt will have to be applied more frequently because it requires humus to hold it from leaching. This costs NZ$35 per ha for 1 kg per ha, which is the amount needed when humus levels decrease.

8. An AgResearch Grasslands comparative trial showed the eighth, which is that urea reduced the rumen fermentable carbohydrate level of pasture by 25%. I'm not saying that other nitrogens would not do the same, but urea boosting grass rapidly over a short period, when soil temperatures are not too low, has a greater ill effect than some other forms of N. Obviously the more N, the less carbohydrate, and our animals on highly fertile pastures need carbohydrate to balance the already high protein.

9. Milk urea nitrogen (MUN) in milk increases with high N applications. See Animal Health > Toxins. MUN in milk is not a problem in New Zealand because on average we use much less N than other countries, and while MUN could be high on one farm, many around it could be low, so the average in a tanker load could be low.

10. If the insect protecting perennial ryegrasses are high with unpalatable endophyte such as AR, (the higher the number the more effective and the more unpalatable), grass staggers caused by endophyte toxicity (ET) will increase. ET, like some other animal health problems, such as nitrate toxicity, snowballs (increases) in the animal, so, when they are going on to high endophyte pastures day after day, perennial ryegrass staggers starts sooner than when they are going on to some affected pastures and some ET-free of safe ET pastures. ET-free pastures are those with cocksfoot, new endophyte-free tall fescues, best phalaris, perennial ryegrass without endophyte, a high clover content, and other grasses.

Bealey NEA2 is a new (2007 in NZ) tetraploid perennial ryegrass with excellent insect protection and the ability to keep growing even in droughts, making it popular in parts of Australia and NZ Northland which is hotter and drier in summer and autumn. See Agriseed Ltd brochures. The more N applied, the more lime needed to counter N's ill effects.

If any of you have got to the high ET stage in your nitrogen and farming policies, the solution is to oversow (See Pasture Renovation for methods) each autumn in late March or early April once moist enough, or spring by mid September with a good long lasting hybrid winter ryegrass, good white clovers such as Kopu ll and Tahora at half a kg per ha each, equals 150 seeds per hectare, so why sow more? If drilling, add Puna chicory and Tonic Plantain for cattle or Lancelot Plantain for sheep. If oversowing do so onto short pasture and trample it. Puna loves hot weather and Tahora is comparatively heat and drought resistant by keeping soils cooler with its dense mat - and it makes more N than any other clover I know. Some will criticise this recommendation. If they do, ask them for a better solution. The Fieldays winning dairy farmer of the year oversowed his whole farm each autumn with Concord winter ryegrass every year. On our two farms we applied it when needed. and When ryegrass has 0.9%Ca, bad heavy metals (Hg, Mn, Al.) in soils are made unavailable and good minerals (P, Mg, B, etc.) more available. Lime also increases clovers and other legumes, saving the cost of nitrogen. On our two farms we never applied N except on new pastures before clovers established, reducing nitrates pollution.

Alternatives to perennial ryegrass and clover type pastures are likely to take off because those who have done a good job of trying them are very happy. A good mix on well managed farms in the Waikato is 5 kg per ha of the best perennial ryegrass, 6 of the best tall fescue, 4 of the best cocksfoot (orchard grass), 4 best phalaris, 2 Kopu ll white clover, 1 Colenso red clover, 1 Tahora white clover and 1 Puna chicory. If you don't manage this pasture correctly the ryegrasses or cocksfoots can take over. When buying pasture seeds ask to see the latest comparative growth comparisons and check them thoroughly - yields, lasting, palatability if possible, dates, etc. One company pushing their winter ryegrass made a brochure which showed theirs as best. Had they included one more month (February) Cordura would have been best because it continued yielding when the one promoted had stopped.

Artificial N can grow more grass so can use up more of other elements. N is often quoted as the cheapest way of growing grass, but I've not seen any allowance for the fertility it uses and the fact that it reduces the N produced by clovers. The figures I've seen quoted are deceptive, and indicate that one could apply just N and keep growing grass at the same cost. Once soil fertility decreases, more N has to be applied to grow the same amount of dry matter so the cost per kg of DM goes up. When calculating the cost of extra pasture grown, other fertilisers have to be allowed for, as does the decrease in humus. Phosphate is often the cheapest producer of extra dry matter in clover based pastures and increases the humus and soil fertility. To grow more pasture apply P up to optimum levels, before N.

Pasture soils in New Zealand under balanced fertilising, mainly with phosphates, lime and the other elements required are still improving as is animal production from them. Those well treated in the pumice areas in particular, have changed from a light sandy infertile Browntop- growing poor soil with only a few cm of topsoil, milking half a cow per hectare, to beautiful deep, dark, friable soils milking 3 cows per hectare, in just a few decades.

Getting the best out of N

Any crop that is not a legume will leave the soil lower in N than before it was grown, so the next crop or new pasture that follows most crops will not do well until the clovers are established and making N, by which time some of the grass plants could have died out if N was low and not applied. Grazing the previous crop will have returned some N, but seldom enough. If available, animal effluent is the best, partly because it gives organic matter.

Don't apply N at sowing, because summer dry weather, cultivation and autumn rains increase it, and if too much is applied, nitrate toxicity can kill animals, especially with winter ryegrasses on their own or even in a mix. Apply it about six weeks after sowing and every six weeks until clovers produce N about six months later. The six week intervals are not exact dates. New pasture on poor soils (low in N) and after maize crops (which remove a lot of N) might need it sooner and more often. Fertile soils which had a grazed crop will need less. Autumn, pasture to pasture sowings should need none, until spring - after the spring flush.

After a harvested crop such as maize, applying animal manure (effluent) to build up the N and humus levels really pays, but then avoid too much artificial N. 40 kg at any one time should be enough.

Once new grass seedlings go yellow, some die, especially if sown too thickly (which is ridiculously common), so use lower seeding rates per hectare (see Seeds) and apply N just **before** they go yellow to avoid this. Try to apply it just before rain.

Aim to apply it close to when most will be used by the plant, not too long before. This means, where possible, spreading it after a crop or pasture is growing and is about to need it, rather than at sowing. Newly sown pastures and crops benefit initially from the soils' release of N which occurs with cultivation so applying more N at sowing is wasteful and polluting, and can cause nitrate toxicity in the grazing animals.

Winter use of the best winter N gives a greater response if the soils are fertile, and there is an abundance of grasses which can grow fast, such as the winter ryegrasses. In many countries where N is used excessively, they grow only winter ryegrasses (tetraploids), even in summer, provided they are in areas that don't get too hot. Sown in spring they can do well in these areas and some don't seed in the first summer.

N should not be used to grow more pasture when the shortage has been created by a lack of - drainage, low general fertility, calcium, other main elements and/or trace elements. The N can leach out of deficient soils which is wasteful and polluting. N gives the best response on fertile, moist, warm soils, growing good pastures.

In clover based pastures it should be used to increase pasture growth when a feed budget shows that a shortage is coming up, due to unusual situations, which doesn't include over-stocking which is common on New Zealand dairy farms. If used routinely on clover based pastures then there it is of little help when a shortage looms. If applied, and the extra growth is not used, it is wasteful and bad for the pasture because clovers will be suppressed, so accurate feed budgeting is important. See Spreadsheets > Dairy or Beef Feed Budgets.

If more late winter feed is going to be required, it should be grown in autumn and carried through rather than try to grow more in winter, all depending on the climate in your area. If applied in early autumn and the resulting stock piled pasture becomes too long, waste occurs when the long growth causes rotting and mould at the base of plants, natural growth stops, and pasture quality deteriorates. If this happens, speed up the rotation to shorten all the pastures longer than about 30 cm (12 inches).

Apply N to fertile paddocks, not to poor paddocks that don't have much good grass and could be needing lime, and apply Ammo (30% N, 14% S). If this is not available then make your own by mixing equal quantities of SoA and urea, which is Ammo .

If urea is used on a frequent basis, clovers, earthworms, soil micro-organisms and humus decrease so N then has to be used continually to get pasture growth. In comparative trials I organised, single applications of urea at 80 kg per hectare (40 kg of N) halved earthworm numbers in those paddocks on a Putaruru, Waikato, light ash soil. Clients have reported the same from many soil types. Reducing earthworm numbers is a very serious problem with very costly bad effects such as animal dung not being moved into the soil, causing an increase in animal parasite infestation, providing fly breeding sites, and causing dead patches of pasture and dead soils. See Soils > Earthworms and see Pests > Flies.

Unless applied in the rain, or when rain is imminent, some of most artificial N can be lost into the atmosphere. Urea is the worst by far. There are now new and treated products to lose less and to leach less. Some manufacturers claim that theirs does not evaporate, but the longer between applying and raining, the lower the pasture response. Do your own trials and you'll see.

If pasture sulphur levels are high then use urea or Ammo, rather than raise sulphur with SoA which will leach and lower potassium and selenium.

If grasses get too long, clovers die out (especially if pasture K levels are high) bare patches will develop and more summer grasses and weeds will fill them. In clover based pastures, white clovers do a good job of covering bare patches, when allowed to do so. Some can spread half a metre each way in a year. Fescues allow more clovers to grow with them than do perennial ryegrasses (some perennial ryegrasses are better in this respect than others), but despite this good fast growing fescues need artificial N in to get the best out of them. Applying some in autumn and some in late spring for summer growth can be rewarding.

Applying N in autumn on spring calving dairy farms will sometimes result in too much long pasture. This can deteriorate at the base causing mould (smell it), reduced feed value and reduced animal intake. Clover suppression and large clumpy ryegrass plants can occur. Using the Feed Budget spreadsheet can reduce the chance of this happening.

A better financial return is obtained from applying it to fertile paddocks with ample organic matter and high fertility grasses.

White clovers may grow in soil temperatures below 10° C but require temperatures higher than 12° C for N fixation to occur. At this stage soil mineralisation occurs and adds 60-70 kg N per ha to the soil, but only if there is humus in the soil. By using N fertiliser you are adding N when the sward needs it and not when clover can provide it (generally maximum output of N from clover is 16-18 days after defoliation). In the cold wet spring I would apply at least 60 kg N per ha and probably 75 kg would be economic in terms of response (>10 kg per ha).

The other point about 12° is that N without S doesn't work as well, then the Sulphate of Ammonia form works better in temperatures around 12°, urea doesn't. None gives a profitable return at 6° or lower.

Watch the weather forecast. Do not apply it if heavy rain is forecast. Very little water is needed to wash urea into the soil and little rain is necessary to cause the reaction to change it to ammonium. Remember that adequate P is essential for good growth in Spring conditions.

A product previously called Tri-Fix now called Triffid apparently reduces N leaching and certainly gives far better yields of maize and brassicas when compared, on trials that I ran and have seen. Protein in maize was increased. I've seen dozens of successes from using Triffid. Its best advantage is that it increases the moisture holding of soils. The increase can be felt by hand which is impressive.

Triffid apparently reduces leaching of N and improves plant absorption of nitrogen. Trials on maize silage at Bill Chynoweth's, Pukeroro Stud in 1993 showed this by increasing dry matter yields by 20% and protein levels by 29%. The increased value on a 20 tonne of dry matter per ha crop at 30 cents per kg of DM for silage would be about $1,200 per ha, for a cost of about $140 per ha for two litres plus the application cost and a higher protein maize silage which is a big advantage.

A Triffid trial on Pasja, a turnip-rape hybrid with a high percentage of leaf and a very small bulb, showed improved feed value and mineral content as follows -

	Triffid	Control	
Protein	0.208	0.183	(14% increased protein)
Ash	0.182	0.169	(= more minerals)
Boron	25 ppm	20 ppm	
Iodine	0.16 ppm	0.12 ppm	

Triffid on maize also improved the analysis. See Silage.

There were insignificant changes in other elements.

Trials on pastures have not shown worthwhile increases, except on newly sown pastures. It does give better soil structure and vastly better hair root growth.

Triffid is a soil improver, not a foliar fertiliser and gives best results when sprayed onto soil with ample water before the final shallow cultivating.

Ruakura DRC Field Day

Trials showed that nitrogen applied at up to 120 kg of N per ha per annum can be profitable, but at higher rates is not. It is very pleasing that NZ AgResearch under the new director Dr John Penno is now doing trials on an economic return basis, rather than just on production as in the past. If they compared urea with the same dollar value of lime, serpentine and boron, they'd see how clovers can produce more than N can and show more profit through milk and animal health than from urea ruining soils.

It is better to put a little, but not less than 25 of N over more paddocks rather than a lot over fewer. However, if the farm has very fertile areas and very poor areas, it is better to apply the N to the fertile areas. The poor areas, if low in humus, P and general fertility will not respond as well to N, but usually will to LimeMag and its synergisms.

Sulphate of Ammonia or Ammo mostly give better and longer lasting results over from four weeks to four months in the Waikato. Many trials showed that urea only gives increased growth from three to seven weeks, hardened soils and halved earthworm numbers.

As with all fertilisers the amount of N to use should depend on -

- Price of land. If land is cheap it could pay to buy more, if expensive, to fertiliser more.
- Return on livestock. It may not be profitable to spend more money on growing more expensive grass if the animal return is low.
- Quality and type of pasture. Some grasses and poor pastures may not respond, very good pastures with ample clovers may not need it. Do trials before spending too much.
- Time of year (cold and drought).
- The effectiveness of clovers. In low sunshine areas clovers may make only 100 kg N per ha pa which is not enough for good pasture in areas capable of growing more, so applying N on a regular basis could pay, depending on the use the extra pasture is put to - dairy, beef, sheep, etc.

Artificial N effects on soils

Too much N annually (the amount depends on the soil, temperature, rainfall, type of pasture, liming and management and whether grazing or harvesting) can lower humus after a few years from the preferred 9% or higher to about 4%. This creates a tighter soil with less moisture absorbing and holding capacity (more run-off in heavy rain on slopes), less vegetation breakdown, and more artificial N needed in the future - a true fertility downward spiral.

The extra pasture grown by N uses up more elements in the soil which are removed by harvesting and/or grazing, so need to be replaced.

University of Wisconsin soils expert Dr. Phillip Barak completed a long-term study of the effects of nitrogen fertilisation on soil total cation exchange capacities (CEC). Nitrogen has acidifying effects on soils and Barak's research has shown that continued use of nitrogenous fertilisers in many soils results in about a 30 to 40% loss of calcium, and a 30 to 40% loss in magnesium. These nutrients we know can be replaced with lime and serpentine. However, the disturbing part of his research showed that nitrogen fertiliser has a strong negative correlation with regard to cation exchange capacities of the soils, and liming those fields does not bring them back.

The Barak trials were done on golf course greens which harvest the grass grown and end up with very low humus soils. When grazing, the CEC is not likely to drop as much because of the organic matter returned from the animal.

There is a close association between sulphur and N, and a deficiency of sulphur is likely to occur where diets contain high levels of non-protein N. Inorganic sulphur can be used by rumen microbes to synthesise amino acids and will improve N retention of growing animals fed sulphur deficient diets. A ratio of N (4.5%) to sulphur (0.4) of about 10 or 11 to one seems optimal for dairy cattle. Sulphur deficiency is characterised by reduced feed intake, lower feed digestibility, slower gains, and decreased milk production.

I've seen soils ruined with excessive N use and become so compacted that the clover nodules could not expand, so were flat and could not fill with N. The first applications of artificial N can give good results, which can gradually decrease as more and more N is applied. This happened in a university dairy farm in Holland pasture I was asked to check because harvested pasture yields were dropping and they could not stop the decrease even with more N. The soil (about 2% organic matter, so hardly a soil) had turned to sand with decreasing yields after 40 years of increasing urea up to 1,000 kg per ha pa.

In the UK during the 1939 to 1945 war they applied urea repeatedly to fighter plane airfields to make the soil harder for the planes to land and take off more easily. In USA they applied superphosphate and urea which made the surface extremely hard. Many Waikato farmers I go to complain about having a hard pan in their soils and give all sorts of reasons, when it is a lack of lime and its synergisms, and the wrong fertilisers.

Urea reduces earthworm numbers so a sandier soil eventuates. Organic matter in soils is stored carbon which is good for the environment. Urea reduces it which is bad for the environment.

Ruakura’s Stewart Ledgard trials showed that 60 kg of N leached from applications of 200 kg per ha pa, and 120 kg of N leached from applications of 400 kg per ha pa. So with the reduction in clover N from 280 to 40 (above), it is a loss of 360 kg of N, which is a 90% loss from the 400 kg application rates. No wonder Ruakura trials showed that it is unprofitable to apply more than 200 kg of N per ha pa.

400 kg per ha increased nitrate levels by two to three times at one metre depth.

These leaching levels were measured on good pasture soils which would have had about than 5% organic matter (laboratory measuring term) which helps hold N.

Grazed clover and grass pastures getting no artificial N leached about 40 kg N per ha pa, so farming methods should try to reduce this. A main source of leaching N is the animals because when they urinate they apply about 1,000 kg per ha of N to the area. So the more N forced pasture, the higher the stocking rate and the more leaching.

No ways of reducing this were given, but I suggest -

- Drain soils correctly so they can absorb and dilute urine for plants to use it, not have it run off the surface of wet soils, or run down cracks in over-drained dry soils.
- Grow deep rooting pasture species such as tall fescues and Puna chicory. They could then use some of the N which leaches to below the depth of shallow rooting species such as perennial ryegrass.
- Encourage deep rooting pasture by deep chisel ploughing, regular liming to reduce aluminium stopping root growth to deeper levels, and using good RP which encourages deep rooting.
- Get and encourage deep moving Terrestris and Longa earthworms which deepen topsoils.

Most people agree with moderation in all things. This applies to artificial N. Use it for establishing new pastures until clovers provide the nitrogen, ahead of shortages, and not as a long term accentuator of grasses.

If farmers in your area can’t grow legumes and say that clovers won’t grow in the area, do your own trials by analysing pasture leaf for the 17 important elements, then use Pasture Analysis Planner and Lime or Fertiliser Planners. Then contact several seed suppliers and asked them which legumes do the best in your area, buy inoculated seed and apply half a kg (50 to 200 seeds) per hectare

Artificial N effects on clovers

There have been ample trials going back 50 years to show that every bit of N applied reduces white clovers - other than helping new clover plants establish. 100 kg per ha of N per annum almost halves them while 360 kg per ha pa reduces them from about 20% to 4 or 5% depending on stocking rates. When using artificial N it is imperative that all the extra grass grown is used, or a double waste occurs - N cost and clover lost.

Artificial N effects on pasture

The effects depend on the soil fertility and type of pasture, and of course on how much is applied. Little, not too often can be OK. In some (especially tropical areas) clovers are harder to grow, but not always impossible, as I've seen in Hawaii and Florida. The large fast growing tropical grasses have to be kept short.

- N increases the moisture content of pasture so lowers the dry matter content, mineral levels and quality.
- Pasture will be lower in sugars (energy) which are essential for good silage and digestion. Applying too much N from any source (animal and poultry manure included) too close to harvesting for silage can produce a high nitrate toxic silage that some animals won't eat.
- Anything that lowers the percentage of clover will lower the percentage of Mg and Ca because clovers have about 20% more Mg and 100% more Ca than most grasses.
- Most mineral levels in pasture will be lower, as is the case with all fast growing plants (spring grass, tropical grasses, etc.). The result is hay or silage with lower magnesium, calcium, copper and boron. After applying N, pastures sometimes take up more sodium for a few weeks.
- N increases the leaf content and slows down maturity, so the plant grows leaves rather than stems and going to seed. For grazing and silage this is good, but if harvesting for hay will mean either cutting later or taking longer to dry, and in the case of wilting silage to a required level, taking longer.
- Clover N fixation is about halved by the amount of N applied, so its cost is more than double that imagined and quoted.
- Increases weed population when clovers stop spreading and covering the bare patches which occur in pastures after pugging, droughts, ryegrass pulling, over-grazing, and natural plant deaths.
- Reduces rust on susceptible grasses and crops. Compost does it a lot better.
- High rates of artificial N can increase ergovaline (part of endophyte that adversely affects animals) levels in some perennial ryegrasses.
- High and/or frequent rates of artificial N increase the susceptibility of some grasses to some fungal diseases and sclerotinia rot in clovers. Heavily fertilised golf course greens are notorious for disease problems. Slow release N is nowhere near as bad.
- An agricultural consultant friend told me that cows on farms using artificial N never look as well as those on farms not using it, and I agree. Reasons could be that they are getting thin soup, so fill up with moisture so don't get as much solids, and get less clover. On all animal clover/grass comparative weight gain trials, clover does the best.
- Fast release N and P fertilisers such as DAP (18-20-0-1), MAP (11-22-0-1), have no calcium so animal dislike and ill-health are common, and superphosphates (0-9-0-11-20 Ca) encourages shallow rooting and pulling out of perennial ryegrasses and rapid growth with low levels of some minerals. With repeated use of DAP, I have seen perennial ryegrass pasture roots so shallow that a 75 mm (3") turf mat could be rolled up like a carpet.
- Bill Chynoweth's well fed cows on his correctly fertilised farm refused to eat DAP fertilised pasture. They walked around the paddock smelling the grass and came back out the gate. He had to hay it.
- Cows on DAP fertilised farms become accustomed to it, but veterinarian Alison Dewes noticed that DAP caused more nitrate problems in animals, and observant consultants noticed more ill health on farms using DAP or MAP.
- N lowers calcium levels. DAP has no calcium, so too much DAP, as recommended by a company in Taranaki, killed cows, especially when potassium was also high and calcium was low. The cows died of severe milk fever symptoms.

In December 2012 a hundred cows died from possible urea poisoning after some got into their drinking water, so be very careful with it. This has happened many times.

When townie friends complain to me about earthworms in their lawns making their shoes muddy, I give them a kilogram of urea to spread per 50 square metres (200 kg of urea per ha). Within a month most earthworms move out. On large lawns, this doesn't happen as well because it is further for them to travel. Large earthworms (Terrestris - night crawlers in US) are less affected by this than the smaller earthworms.

Artificial N effects on animals

To reduce nitrate toxicity, don't graze for 14 days after application of urea, which has worse effects than Ammo.

Half an Otorohanga, South Waikato, farmer's herd wintered on DAP fertilised pastures looked worse (rough coats, lower heads), tested lower in milk solids, and had more metabolic problems than the other half that grazed my correct RP based fertilised pasture.

An Atiamuri clients's cows being fully fed on all DAP and trace element fertilised pastures, looked the worst (very shaggy) in my client group, where others were grazing RP and trace element fertilised pastures.

A dairy farmer who applied MAP to some paddocks noticed his cows become unsettled after grazing them.

Fast growing conditions and/or too much N keep pasture in an immature (lush) state with a poor nutritional balance (extremely high protein and low energy), which is not what is required for healthy animals, hence the increase in metabolic problems when these conditions prevail. Try to not apply N in the months before calving, unless sulphate ones, or if you have to, or are an N farmer, not a clover one, use it sparingly and feed adequate minerals, hay and energy feeds.

1993 research in Florida, USA, indicated that to reduce the incidence of milk fever precalving, cows are best on an anion (negatively balanced) ration for about three weeks, consisting of only 1% potassium (K), 0.3% sodium, 0.3% chlorine, and 0.3% sulphur (some now say 0.4 and some even 0.45% S and I agree), with ample hay. Feeding these achieves good Ca levels in the blood. It was called Dietary Cation Anion Balance (DCAB), but trials were not done on pasture with optimum mineral levels.

Fertilising with too much urea, and/or K, can upset balances and increase MF and grass staggers and lower conception rates. Applying Sulphate of Ammonia or Ammo which have sulphate reduces milk fever.

When pasture K levels are not above 2.8% there are seldom problems, but many pastures are well above this level and have less than 0.4% S. Adequate slow release elemental S helps limit nitrate toxicity as does adequate agricultural lime to keep molybdenum levels above 1 ppm.

Analysing the 17 elements in your pastures at least annually tells you what is in your soil and what you are feeding.

Despite the above N caused problems, if you buy a farm with poor pastures through low P and low legume levels causing slow pasture growth, applying small amounts of DAP or MAP with RP and the required trace elements to get the pasture growing may be necessary for the first year or two. If P is low the legumes will benefit too. S may also be needed. Elemental S is best if rainfall is over 800 mm.

Keep applying small amounts of DAP with RPs with trace elements until your pasture is growing well and legumes are producing the required N, then apply N only as required in the most profitable form for your farm. Don't apply DAP or MAP on their own because they make pastures unpalatable. 40 kg per hectare of coarse agricultural salt helps improve palatability, as do any deficient elements.

Remember that drainage and lime should be corrected before fertilising.

Nitrates & nitrate toxicity (NT)

Applying N to longer pasture ready to be grazed will require grazing it too soon after application when there will be a higher nitrate toxicity risk. This peaks about two weeks after N is washed in.

Annual ryegrasses and short rotation ryegrasses are more inclined to accumulate animal-toxic levels of nitrate, whereas perennial ryegrass, other grasses and white clover pastures are less likely to.

Be aware of urea topdressed Amaranthus, Capeweed, winter cereals, grass crops (maize, millets, Nutrifeed, sorghums), Kikuyu and brassicas.

Applying too much N increases animal nitrate toxicity, especially when fed high-nitrate uptake plants. Once farmers have had a group of animals die within a few hours from nitrate poisoning, they become very careful with the use of N.

Nitrates occur in all green growing plants, but toxic levels are more likely to occur in forages that have been grown under stress such as droughts and frosts when soil N levels are high and molybdenum and sulphur are low. Under these conditions, rain immediately after drought increases nitrate levels dangerously.

Non-accumulators include Timothy, brome-grass, cocksfoot, clovers and lucerne and chicory. Those not mentioned can be in the intermediate range, but don't treat any as safe in dangerous conditions.

Poisoning can occur when nitrate levels are greater than about 2% on a dry matter basis because animals can't convert the excess nitrates into ammonia and excrete it in the urine. Their blood then can't carry oxygen and death can occur pretty quickly. Also ammonia bloat (free-gas bloat) can affect cattle.

To minimise this risk, don't graze for about three weeks after applying nitrogen, unless little was applied and ample rain has fallen. This is not always practical so cattle should be watched for toxicity signs. Hungry animals are more vulnerable so if possible feed them hay or straw first and limit the area given. More pasture can be given later, but be aware that nitrate and ammonia toxicity develop like a snowball.

Clovers don't normally have high nitrate levels and do very little harm to the animals and environment. Measurements in Britain comparing nitrate leaching from soils showed that clover based pastures not using artificial N, leached only one-seventh as much as did soils under pastures getting artificial N. Clovers can accentuate bloat, but New Zealand research has shown that pastures with a high percentage of perennial ryegrass can give as much bloat than just high clover, especially if artificial N is applied. Some clover pastures hardly blow at all. See Bloat.

Applying too much N from any source (animal and poultry manure included) too close to harvesting for silage can produce a high nitrate slightly toxic silage.

When some plants become reproductive (start flowering) their nitrate levels increase, so avoid allowing this by frequent grazing and take care by limiting the amount of high nitrate plants fed. Pasture levels can increase rapidly following rain, especially if warm and after a prolonged dry period. N applied to high fertility pasture just after the first autumn rains, can make normally safe plants lethal.

Fertilising with excessive amounts of quick release growth elements (urea, Sulphate Of Ammonia, DAP. MAP, pasture and crop mixes with N), before or during high growth periods increases pasture nitrate levels excessively, especially if sunshine and some of the buffering elements (sulphur and molybdenum) are lacking.

Applying N, especially DAP to grow silage makes higher nitrate lower feed value silage. Excesses of applied animal manure or effluent increase nitrates and unpalatability.

Few plants, once mature, have lethal amounts of nitrates when growing steadily, however many plants can be lethal when young or when over-fertilised with N or stressed by things like frost, when even maize, which is usually comparatively safe, can become lethal, especially at the base of the plant. In these conditions feeding the whole plant is usually safe, but be careful. If necessary leave the bottom 300 mm (one foot) or more when harvesting it for silage. Rain following dry periods can increase nitrates to dangerous levels.

Also see Animal Health > Toxins > Nitrates.

Stimulants

Stimulants are not fertilisers, so they use the fertility in your soil. Most stimulants boost grasses at the expense of legumes. Grass pastures don't produce as much of any animal product (meat, milk, etc.) as clover based pastures.

A trial in Australia showed that ProGibb (I believe is a gibberallic acid) didn't significantly increase yields over the 76 days compared with the same amount of nitrogen without ProGibb. Reports have said that there is a pasture growth drop after using ProGibb twice or more. The vendors say to not use it more than three times in a year.

Anything that forces rapid growth like ProGibb and urea are only temporary fixes, so deplete useful elements in the soil, which have to be replaced. The resulting fast pasture growth has higher moisture and lower mineral levels than normal growth, so animals have to eat more, but they don't like it, so eat less. After the stimulated growth there is a slump, so it has to be applied again. This doesn't occur the same with the basic growth elements in LimePlus, animal manure, poultry manure or compost or Ammo (30% N, 14% S) is 50% SoA and 50% urea.

DairyNZ, LIC and some marketers calculate the extra growth of dry matter that urea gives against its cost, but they don't allow for the other elements used by the extra dry matter grown, so stimulants are not as profitable as some sales people imply. Animal and poultry manures have minerals, and organic matter both of which hold cobalt, so are better fertilisers, but not for too many times or K can get too high. See the values in the Fertiliser & Effluent Values spreadsheet.

Animal deficiencies

Animals need digestible protein rather than nitrates which is indigestible mostly from excess nitrogen fertiliser.

Nitrogen fertiliser increases crude protein levels. Low N means low protein levels which make pasture lack green colour, of low feed value and unpalatable. Crude protein is the N level multiplied by 6.25.

Protein can be inadequate when grazing poor quality, long, old dry grasses. Applying N to these when they are already old and brown will not help. Either lush pasture, forage crops or good silage (not poor quality silage made from similar old vegetation) must be fed with them, or molasses and a good protein can help.

Animal excesses

Over fertilising with N in any form, and very young sappy high percentage legume pastures can cause high N levels. Initial symptoms are difficult breathing (dyspnea) which becomes severe followed by mouth breathing, violent respiratory movements, very dark red or brown blood cells (check vulvas and/or eyes), frothing at the mouth, frequent urination, muscle tremors and disorientation, loss of animal condition, lower animal consumption production and conception rates, bloat and severe scouring because of high nitrates (crude protein) adversely affecting digestion.

Avoid moving affected animals too quickly and check gullies and waterways for ones that may have fallen in.

The initial symptoms are followed by a rapid weak heart beat, below normal body temperature, muscular weakness, staggering, muscular tremors, blue colouring of mucous membranes and dilation of pupils. Death can occur within hours. Healthy animals are less affected by high N than unhealthy ones.

Excessive nitrates can cause reproductive problems including abortions. Feeding low nitrate silage and hay can help reduce the adverse effects of high nitrate pasture.

Normal Blood Urea Nitrogen (BUN) levels are between 15 and 20 mg per dl. Low is below 15 and high is above 25. Very high BUN levels (above 45 mg per dl) can be a cause of below average embryo survival and pregnancy rate despite good submission rates. Applying too much artificial nitrogen and grazing very lush short pastures can aggravate high blood urea levels.

Another measuring system is Milk Urea Nitrogen (MUN).

See Animal Health > Toxins > Nitrates.

Environmental effects of artificial nitrogen

Fossil fuels are used to manufacture, transport and apply it.

If too much is applied -

1. Soil carbon levels decrease and waters can become polluted.
2. Clovers are adversely affected, so N becomes needed on a continuing basis.

Reducing underground water pollution

Pollution of surface and underground water are important concerns. It is happening under all types of farming, including forestry, but more so under urban areas where lawns can have excessive amounts of N applied because cost on a lawn is not usually a consideration. USA measuring of leached N showed that urban lawns were a major underground polluter.

Leaching

Nitrogen leaches from all soils even when none is applied and even under growing trees and/or pastures. It becomes a problem from pastures when animals are heavily stocked and when excess N is applied. Applying N can increase the animal carrying capacity per hectare which means more dung and urine patches across paddocks which can mean more leaching.

Leaching from pastures can be reduced by -

1. Adequate lime and reactive phosphates to reduce aluminium toxicity. Aluminium prevents some roots (ryegrass in particular) from going deep.
2. Deep chisel ploughing before sowing to encourage pasture roots to go deep.
3. Growing grasses other than ryegrasses that are shallow rooting. Fescues, orchard grasses and Puna chicory go much deeper. Fescues allow more clovers to grow with them than do perennial ryegrasses (some perennial ryegrasses are better in this respect than others), but despite this, good fast growing fescues need artificial N to get the best out of them. Some in autumn and some in late spring for summer growth can be rewarding.
4. It was shown in the 1970s in Italy that planting poplars along waterways uses some of the N from lower soil levels which reduces it entering aquifers and lakes. One row can be planted initially and another planted some time later, but well before the first row is harvested.
5. Draining soils correctly so they can absorb and dilute urine for plants to use, rather than have it run off the surface of wet soils in water, or run down cracks in dry over-drained dry soils.
6. Get and encourage all earthworms, but especially Terrestris and Longa earthworms which deepen topsoils. See Acres USA October 2006 issue.

Ammonium ions are held within the soil structure by organic matter and clay particles, whereas nitrates move freely down to the soil profile with the aid of irrigation and rainfall. The amount applied often determines how much N is absorbed by the plants.

Artificial N use in New Zealand has increased from 30,000 tonnes in 1990 to 400,000 tonnes in 2005. Complaints about no clover have increased at about the same rate. Clover root weevil has been blamed and certainly has done a lot of damage, but a Waikato organic farm had almost no clover root weevil problem while across the fence neighbours did.

Our councils and environmental bodies, advisers and even some fertiliser companies ask farmers to not apply N within 30 metres (about the same number of yards) of waterways or water sources, or further in sandy soils and/or slopes to them and none where 150 kg of N per ha (times 0.9 equals lb per a) pa is applied from effluent.

When over 200 kg of N per ha pa from any source is applied, leaching increases underground nitrate levels significantly and when excessive use of N decreases organic matter levels in soils, leaching increases even more.

Our Environment Protection people are concerned about the increased use of N so they are monitoring its use and have found that immediate leaching into drains after applying urea was evident.

To my knowledge, nothing is being done on improving soils to reduce leaching.

Ruakura research showed that increased milk production used only 5% of the N applied. They also showed that loss into air (volatilisation) from urea applications averaged 12% and that 10 applications at 20 kg of N per ha pa (40 kg urea) caused minimal leaching, whereas 10 applications at 40 kg of N per ha leaching was high and increased levels in water at 3 to 5 metre soil depth. So some would get into the water into deep drains, streams and rivers to higher than the recommended levels in drinking water.

Artificial N loss can occur before it is washed in, especially if applied to warm dry soil and short pasture, and if rain doesn't fall immediately. Trials by Black and Sherlock with granulated urea broadcast, showed that if no rain fell within eight hours, volatilisation losses of 35% occurred. 16 mm of rain within an hour reduced losses to almost nil. However, if 16 mm didn't fall for eight hours the loss could be 10%. Four mm falling after eight hours lost 24%.

So try to anticipate rain and apply N to pasture with some cover. Applying it late in the day is likely to reduce volatilisation because the wind and heat effects are usually less and dew will dissolve some of it.

Artificial N is also leached by rainfall. Immediate heavy rain can leach up to 50% of urea, especially in well drained soils, however wet anaerobic soils lose large amounts from denitrification (gas loss caused by anaerobic soil bacteria). Perfect drainage is important.

Losses are higher from alkaline and cultivated soils than from pastures.

Losses from DAP and sulphate of ammonia are small. SoA locks with calcium and releases N slowly over two to four months for continued pasture growth. Urea gives growth for only about six weeks.

N leaching in wet, cold slow growth periods can equate the amount applied, because while not all the amount of N applied leaches, a greater amount of clover N does, and N levels in the pasture increase, causing higher N uptake by pasture and then higher excretions by animals, which increases leaching from urine patches.

A cow can urinate 10 times a day, each time applying a massive dose of nitrogen to about a quarter of a square metre, at a rate equivalent to as much as 1000 kg per ha nitrogen.

Urine patches are a major source of N leaching. Sheep can deposit the equivalent of 500 kg and cattle 1,000 kg N per ha which is much more than pasture can use in the time it is available. The more artificial N applied, the more high N pasture grown, the more in urine, so the more pollution. Deep rooting pastures will absorb more, while shallow rooting ones will absorb less before the N moves below root levels. When cultivation, deep chisel ploughing encourages deep rooting which allows pastures to use N from lower levels. Fertilising with good fine soft RP also encourages deep rooting.

Excessive use of water soluble N and water soluble P encourages shallow (5 cm) rooting, while lime and good RPs encourage deeper rooting. See Soils.

Nitrates in underground water are becoming a problem in some countries, so all farmers should take heed and aim to prevent levels building up. Some countries aim to keep nitrate levels in water to below 10 ppm. Water at even these levels should not be fed to babies without boiling. Calves could also do better on water that is less polluted.

A study of 1,800 wells in North America found about one-third with excessive nitrate levels, especially in corn and confinement feeding systems, compared with other land uses.

Where large amounts of N have been used, extra proper fertiliser should be applied to make up for the losses of other elements. If this is not done, pasture growth will be slower in late spring, unless the paddocks concerned are really fertile, had animal effluent or had silage and/or hay fed on them.

Keep the N fertilised paddocks grazed reasonably short (from about 2,800 to about 1,700 kg DM per ha), and don't close them for silage or hay if N has been applied within a month because nitrate levels will be high and can cause rejection and/or animal health problems.

Applying N if there will be a natural surplus of pasture within 42 days is a waste.

Minimise cultivation (it releases N) by keeping the cultivating period to two days before sowing. Cultivating and sowing within a day of starting reduces weed germination and gives crops and pasture a better chance of beating the weeds. Doing this even when sowing brassicas has saved having to spray for weeds and resulted in excellent crops. Mouldboard ploughing in early spring won't allow this because it brings up cold soil which then needs to warm up for some crops, but chisel ploughing, which keeps most of the warm soil on top, is faster and allows immediate sowing.

Leaching of N and other elements can be reduced by -

- Having optimum surface drainage - not underground drainage (field tiles or perforated plastic piping) that only work after the soil is saturated and then speeds up leaching.
- Applying adequate agricultural lime for its calcium carbonate ($CaCO3$).
- When cultivating encouraging deep rooting by chisel ploughing deeply.
- Smoothen paddocks to eliminate puddles that hold water.
- Use slow release fertilisers that move down slowly and encourage roots to go down with them.
- Source Caliginosa and Terrestris earthworms and spread them around your farm.
- Installing adequate surface drainage to remove storm water as it falls rather than have it leach N and other nutrients, lime adequately and regularly, use slow release fertilisers rather than water soluble ones.

Urine patches are a major source of N leaching. Sheep can deposit the equivalent of 500 kg and cattle 1,000 kg N per ha which is much more than pasture can use in the time it is available. Deep rooting pastures will absorb more, while shallow rooting ones will absorb less before the N moves below their root depth. When cultivating, deep chisel ploughing encourages deep rooting which allows pastures to use N from lower levels. Adequate lime and fertilising with good fine soft reactive phosphate (RP) also encourages deep rooting. Both lime and RP reduce aluminium toxicity which allows roots of susceptible plants, especially ryegrass, to go deeper.

Excessive use of water soluble N and water soluble P encourages shallow (50 mm) rooting, while lime and good reactive phosphates encourage deeper rooting.

Regulations

A major concern countries have is the pollution of underground water with nitrates leached from farmed soils.

The European Union has set limits on fertiliser use in high nitrate areas. Some European countries's farmers have to keep fertiliser application records. Farmers should not create situations where legislation is necessary, and should also encourage friends and neighbours to be responsible to avoid extreme regulations being imposed and affecting everyone.

Nitrogen use is declining in Europe and North America, while pasture areas for dairying there are increasing, while in NZ, N use is increasing, but is at far lower levels.

Our environmental bodies, advisers and even fertiliser companies ask farmers to not apply N near waterways and none where 150 kg of N per ha pa is applied from effluent.

A good requirement some environmental bodies have is to not spread N fertilisers within 10 metres of a waterway. This may seem far on a small farm and on one with drains 30 metres apart, but consideration should be given to the importance of keep water free of nitrates. Animals usually spend more time camping and dropping their N along the edges of paddocks and drains, so these areas may not need as much N. Where peat soils have been sloped up from drains, the animals camp more on the higher ground, so the lower areas close to the drains are noticeable poorer, so this would not apply then. Peat soils, being high in organic matter don't leach as much N as sandy soils.

Nitrogen & rust

Rust in grasses and some crops is of concern in that yields are lowered and palatability is worsened. Plant breeders have bred it out of some plants - to a degree.

In New Zealand I notice that perennial ryegrasses can have rust, but almost none where they are mixed with thriving clovers making adequate N, especially Tahora white clover which makes more than other New Zealand white clovers. On my parents' farm near Greytown, South Africa in 1952, a crop of oats had bad rust except where compost from animal yards had been spread.

Nitrogen, salt & other minerals

Inevitably, N boosted pastures contain a higher proportion of grass than clover and tend to be lower in energy and some elements, which in the above comparative cost exercise could make N grown dry matter more expensive than indicated.

The massive good fertiliser company ICI Ltd in England, found that applying N decreases the pasture consumption by fully fed cows, but not if salt is also applied with the N. They now sell a combined N and salt product, which their trials showed produced 11.5% more milk solids than straight N. Cows consumed 18% more and were more contented, increasing ruminating time by 9%. The figures look impressive, so before applying N, check that there is enough sodium available in your pastures or apply it at 20 to 40 kg of coarse agricultural salt per hectare. Do your own comparative trials and watch the animals grazing.

Slow release N has been developed for using in young forestry plantings. Pasture users could use it to advantage.

Some farmers apply N to grow more grass, when if they applied adequate LimeMag and trace elements 90% of them would not be so short of pasture. Extra P can grow more pasture for 3 NZ cents per kg of dry matter (1 US cent per lb), and when at adequate levels, grows a lot more in the winter and summer than P deficient soils.

Figures from a three year Northland, New Zealand trial showed that high fertility (adequate P, K, S and pH) increased pasture growth by 100% in winter (from 8 to 16 kg DM per ha per day) and by 80% in summer (from 6 to 11), but only by 14% in spring (from 49 to 56). Extra spring growth has to be harvested for summer and winter feeding which is a cost, so it is better to grow more when needed (winter and summer) if possible. Adequate calcium can help do this.

If your feed budgeting shows a pasture deficit coming, applying artificial or organic (poultry manure) nitrogen depending on the fertility, time of year, etc.

Clover reduces its production of N when N is applied artificially. Nitrogen fertilisers therefore reduce the effectiveness of clovers, not only in their providing free N, but also in providing a much more productive feed than just grass.

Nevertheless, the judicious application of the appropriate N can be well worth while in overcoming feed shortages, provided rain falls soon after application, and the pasture is one suitable to use the N effectively, ice, has adequate good grasses.

When feed budgeting pasture grown with N remember that fast growing pasture has a lower feed value and higher moisture (lower dry matter) content of at least 8%, so allocate that much more. Because a PastureGauge measures dry matter it automatically compensates for this, so no more than the PastureGauge tells you need be allocated.

Using artificial N means the grasses will grow faster and so will use up more other minerals which must be replaced. The faster growing grasses will have fewer of some elements.

As with all fertilisers, measure the financial gain from using N by measuring pasture growth on an N applied area and control area and multiply the extra dry matter grown by the value of it to you. DM value changes during a year being worth less in spring than in summer and winter. However, artificial N can easily produce twice as much DM per kg applied in spring when moisture and warmth are adequate and grasses are growing well, than in summer when moisture slows growth or in winter when cold does. DM is worth a lot to you when short of feed, but nothing when you have a surplus, unless it is for stock piling or harvesting for lean periods.

Avoid mixing SoA with lime or phosphate fertilisers, unless applying the mix immediately and in the rain, or unless cultivating it in immediately, because gassing off of N occurs which is a loss. The mix can also become lumpy.

Animal requirements

Balanced fast growing pastures with about 4.5% N usually provide a lot more more than enough N and protein for animals. The N figure multiplied by 6.25 gives the approximate crude protein (CP) figure. Where bought feed rations are compiled for high milk production, a crude protein of 18% is aimed for. A few decades ago it was 15%. I believe that it would be higher if bought protein was not so expensive. Milk and meat production from grazing animals would be very low from pastures containing only 18% CP (2.9% N). In practise, when the N figure of pastures goes up from 3.5% N (22% CP) to 4.5% N (28% CP), animal production increases. Also, pastures with only 2.9% N would be very slow-growing, low-producing and unpalatable. Pasture CP levels vary between 20% (3.2% N) and 31% (5% N).

The high levels occur in urine and dung patches and after more so after artificial N is applied.

Animal Deaths

Some talk and write about supplementing cattle with urea. This is not new. We fed less than 10% of urea soaked into poor quality tussock type hay to cattle on dry feed during droughts in South Africa in 1950, before learning that nutritious minerals were of more importance. We had no deaths, but some did.

During droughts and in winter when good feed can be limited, dry low-quality hay can bind and constipate ruminants and kill them both ways. Soaking it as below can reduce this problem.

In many countries on fast growing high quality grasses there is often too much urea in the animal's system, but some NZ farmers and some consultants suddenly heard about feeding urea in 1986 and tried to increase animal production with it. Cows died then as they had in the 1940s and in most years since by people feeding urea in one form or another.

Milk can become overloaded with urea and in some countries 'milk urea' is measured daily. It is not measured in NZ because it doesn't occur.

Sugars (energy) and bulk are needed to digest the protein in urea, so molasses or molasses based products were supplied after mixing it with water (hot to start with) and low-protein poor-quality roughage soaked in diluted molasses and urea or it was poured over the roughage at 1 kg of molasses per head per day, for predigestion before entering the rumen. A maximum feeding rate of urea has been recommended, but all feed is different so needs checking first. Feed molasses and an edible protein if needed rather than urea.

Since the 80's a sea-salt based soluble mineral mix gave better results than molasses and protein. In 1984 we fed Solminix in drinking water through a dispenser while grazing dry cows on old, dry, grain harvested maize stubble in early winter with excellent results. Minerals are often more important that protein. Lick blocks won't achieve this because as Cornell Ag University wrote, a cow's tongue would wear out before she got enough. Loose licks are second best, but best by far are soluble minerals of sodium, sulphur, magnesium, zinc, cobalt, selenium, boron and iodine fed at 0.006% of live weight or 30 g per 450 kg cow per day that costs only about NZ 4 cents per cow per day, for tremendous benefits.

Urea is disastrous fertiliser and not a food. **NEVER** add urea to drinking water. A Waikato farmer doing this had cows die and some were so distressed that they had to be shot.

If N has to be applied, such as on new pasture until clovers are producing it, use urea and an equal amount of sulphate of ammonia which always grows more pasture over a longer period than urea for about the same cost, because N needs S to work, and the mix doesn't evaporate and leach like straight urea does. I've got farmers to equal cost comparative urea and sulphate of ammonia fertiliser trials and SoA wins. Ammo, which is half urea and half sulphate of ammonia, is a far better nitrogen fertiliser because it applies some sulphur which is needed to make the N work and is healthier for animals than all urea which is nitrogen without sulphur.

Urea poisoning has been confirmed as the cause of deaths of 122 cows on a south Taranaki dairy farm. The cows were in a herd of 600. They used a urea spray tank to fill their drinking troughs."

It was rinsed, but should have been washed thoroughly and water allowed to stand in it and then disposed of.

If the cows had had no access to water before the troughs were filled, sudden gorging might have exacerbated their reaction to urea.

Massey University toxicologist Kathy Parton said cows would show signs of toxicity 30 minutes to an hour after ingesting excess urea.

Multiple use of containers should be avoided.

Also see Animal Health > Toxins > Nitrates

Soil and pasture requirements

The N level in growing clover based pasture should be about 4.5%, but will vary with moisture and the season. See Pasture Analysis. Twenty to thirty percent healthy, productive, clovers in temperate pastures on good soils and fed balanced fertilisers, will supply most of a pasture's N requirements when the soils and grazing animals are managed correctly with minimum trampling, and correct drainage. However, there will be times when pastures will respond to artificially applied N.

Several experiments have shown that for every kg of artificial N applied (at normal rates), half a kg less clover N is produced and less clover is grown, so the feed value of the pasture declines. Low N use and keeping pastures short is not as bad as high N use and allowing pastures to get long (over 2,700 kg DM per ha - about eight inches).

Soil acidification is faster when using artificial N, but can be restored by applying approximately the same weight of lime.

Soil, plant & animal requirements

The ratio of sugars to protein can be about 3:1 in immature pasture, and 6:1 in mature pasture a few weeks later. Excess N and potassium (K) reduce the sugar levels of pasture, which increases the nitrate levels. Correct boron levels increase the speed of sugar manufacture by plants. Molybdenum helps reduce nitrates in plants and in the animal's digestive system, but avoid excesses. See Elements > Molybdenum.

Cattle generally don't like high nitrate levels in pastures or crops, but do like pasture with a high sugar or energy content, so they graze these first, but sheep can be attracted to urine patches especially in low fertility pastures. These patches are higher in nitrates.

If only high nitrate pasture is available, as occurs after fertilising with diammonium phosphate (DAP) and/or MAP, cattle eat less, so production suffers. Uneven grazing of pastures occurs, because the ungrazed patches have higher nitrates which is one of the reasons that cattle leave pasture around dung and urine patches, and they push through road fences to graze unfertilised pasture. This problem is accentuates when artificial N is applied.

Soil and pasture deficiencies

Pasture N deficiency symptoms include -

• Pasture lacking green colour, slow growth, the greening from animal manure and urine showing up more strongly, low fertility weeds growing, In these cases, the reasons for the poor legume growth and lack of legume N production should be corrected.

• A yellowing of the older leaves of some plants while S deficiency shows on the newer leaves. If both N and S are low yellowing can be on both parts.

• Slow growing patchy yellow grasses with the only green grass in the urine and dung areas, while the surrounding pasture is yellow and clovers are stunted. Grasses can have slender fibrous stems and rust. Lower leaves may show yellowing first. Low fertility grasses and flat weeds such as dandelions, sorrel and plantain thrive.

Low nitrates don't upset animals, but can lower palatability and protein, and therefore animal production, especially in fast growing and high producing animals which need ample protein.

Soil and pasture excesses

Winter ryegrasses (Italian) have more crude protein (CP) than hybrids which have more CP than perennials except in summer when perennial ryegrasses keep growing, provided moisture is available. Tetraploids have more than diploids, leaves have more CP than stems so if trying to increase CP as when feeding maize or its silage, keep pastures short and leafy.

Leaf diseases also reduce CP levels.

When soil N levels become too high, pasture becomes less palatable and the plant uptake of potassium, sulphur, magnesium, copper and calcium decreases, which is bad for animal health, resulting in scouring, increased metabolic problems and low production. This does not apply as much with Kikuyu and some tropical grasses.

When soil N levels become too high, pasture becomes less palatable and plant uptake of sugars decreases, which is bad for animal health, resulting in scouring, metabolic problems and lower production. On top of this, because the energy level of the pasture decreases, animals don't get sufficient energy to digest the high nitrate content of pasture. In trying to do so the animal uses its fat reserves, causing it to lose inside and outside body condition, produce less, and, if prolonged, become thin and unhealthy.

Clover sclerotinia rot increases, and legumes don't admit rhizobia into their roots to manufacture N when the soil is already rich in N.

Be careful of trial results which are done on fertile high humus soils with 10% humus and on pastures which have not had N before, because they will show better results than on the same soils after several years of N use which depletes humus and lowers clovers. The actual rate and the effects depend on circumstances such as rainfall, climate, soil type, organic content, amount of clover, type of grasses, other fertilising and liming, and whether harvesting the pasture or grazing it in situ.

Scientists at the agricultural research university of Groningen in Holland were deeply concerned about having to apply more and more urea each year to try to maintain the same pasture growth, but they were losing ground (literally too). When they heard I was in Holland, they asked me to, “Come and give an opinion”, as have agricultural universities and research centres in New Zealand, South Africa, USA, Canada, Japan, Korea and other countries. The Dutch soils had become like a weak mix of concrete almost completely devoid of organic matter after decades of using urea eventually up to 1,000 kg per hectare per year. There were only the very large Terrestris earthworms and no soil organisms which make the humus and have a nice smell. The pasture needed no more N, high N producing clovers, gypsum to supply calcium quickly and to loosen the soil and a pasture analysis to determine deficiencies. Grazing rather than harvesting and farm yard manure were needed to build up organic matter.

Beware of comparisons between buying N to grow grass at half the cost of buying hay. The hay will bring organic matter and fertility onto the farm, and supplement lush pasture to give a better balanced diet, while the N will lower humus and use up other elements to grow pasture and could accentuate an the over sappy pasture problem.

High levels of ammonia (NH4) can retard growth and restrict potassium uptake, whereas excessive levels of nitrates (NO3) are accumulated in the plant. Too much NH4 can lower the pH around the roots by up to two (pH 6 down to pH 4), which can affect the availability of nutrients and biological activity around the roots. The lowered pH around the roots is believed to be partially responsible for the incidence of diseases. Once ammonia is converted to nitrates it is either taken up by plants or leached.

Excess N in soils can be leached and cause pollution of waterways. Excesses in plants reduces vitamin A levels.

Animals can consume lethal amounts of high nitrate feed in half an hour, or, if levels are not as high, over several days, and gradually suffocate with nitrate toxicity.

A pasture analysis can show that calcium, magnesium and other elements are required.

Andre Voisin's Soil Grass and Cancer book, sites scientific trials showing increased artificial N having a detrimental affect on animal mineral levels.

Nitrification loss inhibitors

Nitrification inhibitors being developed in many countries slow down the conversion of ammonium-N to nitrate-N and thus reduce nitrate-N leaching and nitrous oxide losses from the soil. Nitrate-N losses are claimed to be reduced by 20 to 60% and increased pasture production of 5 to 10% is claimed. Some figures are half these.

Irish trials show 8 to 9% yield increases with N applications of 100 kg of N per ha and a greater responses in pasture production, especially at rates of 100-150 kg N per ha as a single application. This extremely high application rate is not used in New Zealand and is against environmental body recommendations of a maximum of 40 kg of N at any one time and no more than three times in a year. I think that no more than one application a year is better, followed by the other elements needed, based on pasture analyses, not on soil tests. They didn’t say which N was used, which shows that they don’t understand N.

Nitrate inhibitors may help reduce the leaching of N, however the inhibitors could also inhibit good things in soils as was done by some liquid products with the preservatives used to stop the seaweed and fish oil from going bad. Some killed soil bacteria which then released N which greened the pasture for a short time, but eventually the pasture went brown and pasture production dropped dramatically. No farmer used them for longer than four years by which time soils and pastures had deteriorated.

Anti-leaching agents for urine already exist, but are often not cost-effective. Such treatments cover entire pastures, when only 25 per cent of that area may be made up of urine patches in any given year. On average only 10.5 per cent of the nitrogen in grass, silage or other feeds is converted by grazing animals into milk, meat, eggs or wool - the remainder is excreted in dung and urine.

Wait until many of the best farmers are using the commercially promoted nitrification inhibitors profitably before using them. There are better ways of reducing leaching such as deep chisel ploughing, liming more than AgResearch recommends to encourage deeper pasture rooting, etc. See the chapters on Draining, Cultivation, Calcium, Nitrogen, Phosphorus, Soils and Earthworms.

Which N?

There are several forms of N fertiliser, so deciding which one to use can be difficult. Not all forms are available in all areas.

When soil S levels are high, urea can be the best buy, when S is optimum or low a product containing S may be best. When calcium is low, use one containing this element such as calcium nitrate, when sodium is low use one with it, or apply it at the same time. When magnesium (Mg) is low in a pasture analysis be careful to not apply too much N, especially if near-calving cows are grazed on it because metabolic problems can occur.

Urea has 46% N all in ammonium form and doesn’t keep pastures growing for long on the many farm comparison trials I’ve done, against the same dollar value SoA which is 10.5% nitrate N and 10.5% ammonium N.

If the soil is cold as in winter and S is low as it usually is in winter, unless having applied an elemental S, use SoA.

The liquid nitrogens coming on the market don’t have the solids that dry nitrogen fertilisers have. Some get growth by stretching plant cells which can’t go on forever.

Do comparative trials on an equal cost basis per hectare

Ammonium nitrate (34-0-0)

This contains nitrogen in both the ammonium and nitrate form, is less subject to volatilisation losses into the air than urea when surface applied, but is more subject to leaching losses on sandy soils.

Ammonium Sulphate Nitrate (ASN) 26-0-0-14

This contains 7% nitrate N, 19% ammonium N and 14% sulphate sulphur. Nitrate N, being immediately available is more effective in cool weather. Soils at 10°C (50°F) at 100 mm depth take twice as long as soils at 20° (68°F) to make the ammonium N available. Soils at 5°C (41°F) take three times longer than those at 10° (50°F), or six times longer than at 20° (68°F). Trials on soils at 6°C (43°F) showed that ASN, although more expensive per kg of N, was more profitable than urea at growing pasture, but in warmer soils it is about equal.

Calcium Ammonium Nitrate (CAN) 27% N & 8% (Different in some countries.)

CAN has 13.5% nitrate N, 13.5% ammonium N and 8% calcium. N loss into the air (volatilisation) is minimal from CAN and it is less acidifying than some.

This form of N should be used when economical and -

- When rain may not come immediately to wash it in.
- On water-logged soils after heavy rain.
- Before dry periods.
- During cold weather when soils are below 6°C (43°F) @ 100 mm.
- When a longer continuous release is required.
- When cultivated in at sowing to avoid seed damage.
- On both low and high pH soils.

High yielding crops such as maize that grow for five months can run out of N when fast release N is used at sowing, so CAN helps avoid this and reduces leaching which can occur with fast release N at sowing, simply because the seedlings and young plants can't use it all as quickly as it is available.

Sulphate of Ammonia (SoA) also called Ammonium Sulphate (NH4SO4) 21-0-0-23

SoA has 10.5% nitrate N and 10.5% ammonium N with 23% sulphate sulphur. It is a by-product of the steel, coke and gas industries. S is essential for artificial N to work and for the fixation of nitrogen by legumes so mostly achieves better pasture growth than urea, even when applied at slightly lower N rates per hectare. Some find that urea gives a faster response, but many have found that by grazing time SoA fertilised has more. It is a more stable form of N and has S which N needs to work.

Ryegrass has a greater affinity for ammonium than nitrates at low temperatures and it has been shown that at temperatures below 8°C (46°F), ryegrass takes up 70% of its N in the ammonia form.

SoA has been accused by urea vendors of making soils acid, however, the small amounts used on pastures in New Zealand have little effect in this respect. Both SoA and urea take only about their own applied weight of good quality (>95% CaCO3) agricultural lime to reinstate levels. Usually more lime is beneficial. Organic matter is also acidifying, and no one is against it, so take the criticism from whence it comes - opposition sales people.

SoA can continue growing extra grass for up to four months after application while urea won't.

This has been proven in about 50 (mine and clients') Waikato equal cost per ha comparative trials on many soil types, when SoA has ALWAYS given better results over a longer period which means you don't get the slump that occurs after urea. Some farmers with low S soils have seen little response from urea.

Elemental sulphur which is usually applied with RP's keeps S levels up where it should be for nearly a year whereas sulphate S in superphosphate pushes pasture levels up to excessively high levels, then after a few months it leaches (taking potassium and selenium with it) so levels drop to below the optimum. Elemental S does not leach, but is gradually made available by soil bacteria breaking it down.

SoA locks with calcium and releases slowly over one to three months so can be applied in larger amounts. For SoA to work to best advantage, soils must have adequate Ca.

Don't apply lime at the same time as a nitrogen-containing fertiliser, because they will combine and release ammonia gas, wasting valuable nitrogen, and it could be a waste, because in acid soils lime balances the soil's ions by increasing cations, so briefly makes nitrogen available, which is a reason for pastures greening up about a month after applying lime. The long term increase in pasture growth after applying lime could be because clover nodules need molybdenum which calcium makes available, so then produce more nitrogen.

Apply Ammo to new grasses at about 130 kg per ha each time, as soon as any yellowing shows. This can save applying it again a month or so later. This can’ be done with urea, because it leaches.

Some say that golf green keepers use SoA to kill earthworms. They also do so because it is mostly better than urea. No farmer would use the excessive amounts that they use, so its effect on earthworms and acidity don’t apply on farms.

It is the S in SoA that lowers the pH, as does the S in superphosphate and elemental S in any fertiliser, so again points are being mixed. However S is essential for clovers and animals. Green keepers seldom apply lime and don’t aim to correct the acidity. Some distort the soil’s optimum levels so much that they have to spray with all sorts of chemicals to keep the grasses green.

SoA absorbs moisture and then goes hard. If mixed with other fertilisers the mix will go hard after a few days, depending on the humidity and how well sealed it is.

I hope that all farmers everywhere apply N to newly sown pastures when they need it, which should be about five weeks after sowing and ABOUT every six weeks until clovers produce sufficient N. Don’t apply any at sowing, because cultivation and rain provide enough until the grass is growing, and if too much is applied, especially when sowing winter ryegrasses on their own or in a mix, nitrate toxicity can adversely affect and or kill animals.

Make sure that N is applied before grasses show signs of needing it, especially if tall fescues are grown because they are slow to establish and need all the help they can get. N starved grass seedlings can die without you noticing it.

The six week intervals between applications are not exact dates. Sulphate of ammonia (SoA) lasts longer than urea. Also, it depends on the pastures sown, for example fescues need more than perennial ryegrass to help quick establishment.

New pasture on poor soils (low in N) and most soils after harvested maize crops (which remove a lot of N), might need N sooner and more frequently, and for longer. Fertile soils which previously had a grazed crop will need less because of the animal manure returned. Autumn sowings after good clover based pasture (grass to grass with no crop in between) should need none until early spring. Applying it before needed can increase the chances of nitrate toxicity.

Aim to apply each dressing of N just before the pasture starts to yellow, not after. Once seedlings go yellow, some die, especially if sown too thickly.

Ammo 30-0-0-14

It is 50% SoA and 50% urea. It has less S than SoA which is better for crops such as brassicas, and where S is adequate.

If you can’t buy Ammo, mix urea and SoA in equal quantities.

Urea 46% N

Urea is the highest analysis dry nitrogen fertiliser, all of which is usually immediately available, so it should not be applied to pastures at heavy rates, because the pasture can't absorb it at the rate at which it is available. Urea's useful pasture growing life is usually less than six weeks. Urea is the cheapest N to buy, but risk of volatilisation is high.

It is made by extracting N from the air which has about 78% N. Urea is the cheapest form of N on paper, but not always at growing pasture. It has no sulphur which is needed to make N effective and it loses a lot into the air and is short lived.

Urea cannot be mixed with other water soluble fertilisers, because the mix turns into a difficult-to-spread thick substance, but with RP’s it can be okay if spread within a a day or two day of mixing.

Urea is recommended by some people because of its lower cost per kg of N and was previously liked by farmers because it is in granular form so easier to spread (Ammo and SoA are now granular), but N needs S to work with it, and that is why applying the same dollar value (cost) per hectare of sulphate of ammonia or Ammo frequently gives better results. Most New Zealand soils are low in sulphur unless elemental sulphur is being applied with fertilisers in adequate quantities. Northern Hemisphere soils sometimes have excess S from factories and other forms of pollution, although this is now decreasing and in the future farmers there may have to apply S for clover growth, and to get the optimum benefit from N.

Urea is claimed to not leach unless heavy rain falls soon after application. Under the cold winter conditions of Ireland and England, 90% of the urea applied is converted to ammonium ions within two days and then does not leach. However, New Zealand research shows that nitrate levels build up in waterways when too much (depending on soils and rainfall) urea is applied. Legumes in pastures put about 6 mg of nitrate nitrogen a year into waterways while 200 kg per ha of N applied over a year puts in 13 mg, and 400 kg per ha of N applied puts 27 mg in to waterways.

Anhydrous ammonia

Its disadvantages are that it is hazardous to handle and it must be injected into the soil, which can roughen the paddock.

Mixes

Diammonium phosphate (DAP) (18-20-0-1), MAP (11-22-0-1) and most crop fertilisers contain N. If P is low, DAP or MAP can give more pasture growth than straight N, but reactive phosphate and SoA will usually grow more dry matter and do so more economically, and most importantly, animals will prefer the pasture and legumes will do better, because they need sulphur. When Superphosphate was first applied to New Zealand pastures in the 1800s, the extra pasture growth was attributed to the phosphate, but it was later found that the sulphur also contributed substantially.

Animals unaccustomed to grazing artificial fertilised pastures can refuse or eat less pasture fertilised with DAP or MAP.

Organic nitrogens

Blood meal, blood and bone, fish seaweed fertilisers are examples of these, but are generally uneconomic for most pasture growing, because of their high cost per kg of N.

Animal based fertilisers

Blood and bone fertilisers can make animals become excited to the extent that they break through fences. If animal residue fertilisers have to be used, either use sheep ones for cattle and visa versa, or accustom the animals to the smell gradually.

Use only sterilised animal products to avoid spreading diseases.

I would not use blood and bone fertilisers made from sick animals, because grazing animals could eat some of it with unfortunate results. Some claim it is heated enough to kill all, but parts could miss the heat.

Poultry & broiler manures

These help build up humus in soils, which can be useful after years of cropping, can grow plenty of grass and seem to encourage clovers to the extent where bloat can be a problem after a few years of repeated use.

Maize silage grown on the same paddocks reduces the soil organic matter content, so some growers are buying poultry manure which has increased its price.

Some poultry manure includes litter in the form of shavings, sawdust, paper, etc. The more litter the lower the value. Be careful that the litter is not toxic as with some timber (eucalyptus, treated timber, etc.).

Don’t exceed four cubic metres per hectare (two cu yards per acre) per annum for more than two years, unless soil humus is very low and problems are not occurring. Analyse pastures to avoid excesses and correct any deficiencies.

As with all animal manures, the fresher it is the better, unless composted completely. Apply it just before rain to reduce N loss into the air.

Grazing animals will eat poultry manure so be careful to avoid diseases in poultry which can kill other animals. About a hundred cattle died on a farm in another country after feeding diseased poultry manure in concentrates. Apply it to just grazed pasture to reduce the risk of consumption. Old polluted manure should have lime and/or reactive phosphate (depending on the soil's requirements) added and be composted until it has no smell and is even (all decomposed).

Waikato, poultry manure, pure (no litter) & fresh.

N	P	K	S	Mg	Ca	Na
4%	2.5%	1.5%	0.5%	0.4%	5%	0.5%

Poultry manure with litter.

N	P	K	S	Mg	Ca	Na	
2.0%		1.0%	0.5%	0.4%	0.30%	4.3%	0.4%

The 1.5% and 0.5% of K don't sound much, but poultry manure is usually applied at several tonnes per hectare, and your soil may not need any K. Because it contains Ca and sodium both of which reduce K leaching, several applications can increase K levels and cause severe bloat.

Pig (Hog, Swine) manure

This can have an excess of copper, so monitor it and use as suggested for poultry manure above.
As with all animal manures, the fresher it is the better, unless it is composted completely.

Animal manures

In many countries the spreading of animal manure on snow or in winter is banned for fear of runoff into waterways. Wintering animals on shallow snow should not cause a problem, provided they are not mob stocked too closely. Trampling snow can melt it and trampling animal manure spreads it. During wet weather try and do these things away from waterways.

The University of Wisconsin did a study in the late nineties and found that the content of manure pats were very stable hardly changing after being exposed to the cold for six months. Manure pats deposited by animals on deep snow froze and held together, and only flooding was able to move it.

The University of Minnesota at their Morris Experiment station installed a ground water monitoring system around an area where they wanted to try an outdoor-bedded pack. Nutrient leaching from the bedded pack was negligible, but I don't know what it was like after a few years.

Mechanically spread manure and slurry can be washed in to waterways in heavy rain so spread them well away from waterways. Rain can also wash harrowed cattle pats, while undisturbed ones aren't much of a problem because heavy rain can run around them.

Farmers in many countries have been fined for polluting water and Milwaukee farmers were blamed for the crypto-bacteria in drinking water, however, an analysis showed the crypto came from wild Canadian geese, not from livestock.

Liquid Fertilisers

These, even if effective, are usually much more expensive per kg of element, so while they may do a good job on small gardens and perhaps orchards, they are seldom cost effective or sustainable on pasture. Some vendors make claims, which could be correct, but possibly only if the soil already had adequate amounts of all elements. It is easy to prove anything and get honest responses. Remember the researchers' claim that, pay them $100,000, and they'll prove anything.

To qualify this -

1. I've done dozens of a variety of comparative liquid seaweed and fish product trials on our back lawn of dwarf perennial ryegrass which is well fertilised with all elements (it is only 400 sq m so doesn't cost much to keep it looking well), and Triffid was the only liquid one to improve growth noticeably, I believe partly because of its ability to reduce the leaching of N and so make it available over a longer period, and partly because it encourages better soil structure and vastly better hair root growth. It doesn't work on poor hungry soils.

2. I can't remember how many times my phone has gone and been told, "I changed to liquid seaweed or fish fertilisers two or three years ago and now I'm growing less and less pasture each year".

After that it usually takes three years of proper fertilising to get the pastures yielding to their potential again. This could be done in less time, but the cost to achieve it in one year is usually beyond most farmers. Quite often they went into liquid fertilisers because they were broke and saw seaweed and fish fertilisers as being cheaper than solid fertilisers. Some liquid seaweed and fish fertiliser sales people do suggest that their fertilisers are recommended as well as solid fertilisers. Again I have not seen any benefit from them. They all have a sterilising preservative such as formalin. When applied to soils the formalin or equivalent can kill some of the soil organisms which then become a plant food high in N, so pastures turn green. Most seaweed and fish fertilisers are sold by the litre or gallon rather than by the ton, and vendors say that you don't need much. The price per ton is usually about $3,000. Fertiliser should be priced by the amount of nutrients rather than the number of litres. Remember that liquids have a high proportion of water and very low percentages of elements. Most seaweed and fish fertilisers can work until soil elements drop below critical levels.

Some concoctions suggested by consultants have killed pastures, plants and animals, so be careful and do small trial areas first, especially on orchards where some sprays have defoliated trees. Don't exceed recommended concentrations and pre-wash spray equipment thoroughly.

Conclusion

You will have noticed that I recommend pasture analyses rather than soil tests. This is because soil tests are inaccurate and unreliable. The NZ Department of Agriculture and Hill Laboratories have been trying for 50 years to measure S and K accurately in soils, and most trace elements can only be measured in plant leaf. Even elements such as calcium and phosphorus are measured much more accurately in pasture analysis than in soils. Many farms are suffering from all sorts of problems such as weed infestation and animal health, simply because pastures are not analysed for all 17 elements and correct levels achieved, starting with calcium. When it is correct (See the spreadsheet called Pasture Leaf Analysis for optimum levels.) many others improve, and become easier to get to their optimum levels.

The use or otherwise of artificial N is a strong personal attitude in many people. From all the above you may conclude that I am a bit anti the over-use of artificial N. You are right. While one tries to give full information and allow readers to decide, there are times when one has opinions based on what one has learnt and what one sees as a requirement for the future. Farmings' Economic Farm Surplus (profit) figures have shown no financial benefit for repeated use of N, despite increased grass growth, so those recommending its use for other than emergencies should be careful. Continued use of artificial N uses up soil humus, which is even worse than the clover depletion that excess uses in particular, causes, because after a while the soil becomes like sand and almost hydroponic farming, which requires more frequent N, and perennial ryegrass won't survive in low humus soils. Use the spreadsheet Pasture Silage Hay Crop N Costs to calculate costs and benefits on your farm.

Artificial N lowers soil humus, which holds N (cobalt, selenium and some other items) and reduces leaching, especially of important elements such as cobalt, which can cost NZ$40 per ha pa to maintain in low humus soils.

Too much nitrogen from chemical fertiliser and/or from effluent are the main causes of high nitrates in herbage which can cause acute toxicity in cattle, sheep and other livestock resulting in nervous collapse, abortion, bloat and even death.

As the animal carrying capacity of each hectare increases, nitrogen leaching from urine and effluent disposal become more of a problem.

Spreading effluent on poor paddocks or fields to be cropped helps in three ways -

1. It reduces the amount spread on already high N pastures.
2. It increases crop yields substantially.
3. It reduces rust and other health problems in crops.

Selling effluent from oxidation ponds to maize growers helps both the seller and the buyer.

High BW (Burrowing Worth) earthworms (Caliginosa and Longa are the most active) can help solve low N (they have turned poor pastures green), but will not survive if urea is spread repeatedly because each application at average rates (80 kg/ha) halves earthworm numbers. They can also decrease in numbers with decreasing calcium and organic matter levels. Earthworms turn organic matter into humus.

A major farming problem today is the Western World over-production of all animal products for those who can afford it, which is a main cause of low prices, so if N increases production without increasing net profit, you are adding to your main problem.

The following will interest USA and other readers. Dave Forgey, a very successful grazing dairy farmer of Logansport, Indiana wrote the following on graze-l in September 2000.

"Starting in 1998 I took 30 paddocks and in four applications I covered a third of each paddock with 120 units of N per acre. On the second third I used only 60 units of N per acre. On the remaining third I used no additional N. Based on observation only, we have seen no additional growth and no selection preference by the animals. I have many visitors to the farm and I always ask them to point out the areas of the paddocks which gets the additional nitrogen. None have been able to do anything but guess. Finally this year, Forage Specialist, Keith Johnson, was able to pick out the areas which had no Nitrogen by the fact that they had more legumes. At the 60 units of N application there was still about the same amount of legumes, but at the 120 level legumes in the stand were considerably less."

The decision is yours

Now you've read the evidence, it is up to you to decide which of the two routes to take -

Option 1. The judicious use of N such as -

- Only when feed shortages are forecast which is well before summer dry periods and well before winter. N won't grow much when too dry or too cold.
- A little for high yielding grass crops such as maize. Effluent, poultry or pig manure are best because maize silage lowers organic matter. See Forage Crops > Maize.
- On new pastures apply N when it starts to show a deficiency by going brown, and no more than twice a month after sowing (not at sowing because cultivation releases N), until clovers are producing sufficient N. A little N helps clovers establish, too much makes grasses suppress clovers.
- Before correct fertilisers have been applied to give optimum pasture leaf levels of Ca, P, S, boron, cobalt and molybdenum, to feed the clovers perfectly.

Option 2. Repeated use of N on all pastures resulting in -

- Clovers reduced to almost none.
- Shallower roots and increased leaching of elements.
- Earthworms and soil microbes disappearing.
- Soils almost inert with little organic matter.
- Nitrates in waterways and aquifers. Two Waikato cases I know of caused staff to be sick and leave the farm after nitrates in bore water increased, because of repeated high use of urea.
- Animals and milk with high nitrate and high MUN levels. These were not in New Zealand.
- Increased pest attacks.
- Increased ryegrass pulling out, caused by too much N and water soluble P like superphosphate, rather than lime and reactive phosphate. These make New Zealand's already wet acid soils more acid, which make heavy metals more available. LimePlus make heavy metals less available and good minerals like magnesium more available.

Remember that sulphate of ammonia grows more grass, and clover, than urea, costs less per kg of pasture grown, and is healthier for the soils, pastures and animals.