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Inputs for turfgrass managers and sod growers: Marketing vs. science-based information with emphasis on Australian experience

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Abstract. Industry structure and supporting resources are discussed in relation to information on plant nutritional and biostimulant products and concepts. Critical commentary is provided on examples of such products and services before considering ways in which decision-making by turf managers and sod growers can be improved in the future.

Keywords: Soil testing, fertilisers, soil amendments, biostimulants, pesticides.

Introduction

Successful turf managers and sod growers need to obtain value for money in terms of inputs used to produce, manage and maintain turf to high quality standards. However, the ever increasing number and range of products and services being marketed to the turf industry, both in Australia and worldwide, is making it both more difficult and more challenging for them to assess the claims made by the commercial promoters of these. The market for fertilisers and soil amendments is essentially unregulated: a case of buyer beware! Pesticides, on the other hand, are well regulated (by the Australian Pesticides and Veterinary Medicines Authority and similar regulatory bodies in other countries) as to the claims made in relation to registered products; even so, there is still sufficient "wriggle room" for companies seeking to maximise their markets for each product, which on occasion can lead to their legitimate use for dubious or ineffective practices.

The present paper looks at industry structure and supporting resources in relation to nutritional and biostimulant products and concepts; provides critical commentary on examples of such products and services; and discusses ways in which decision-making by turf managers and sod growers can be improved in the future. As such, this is not an exhaustive review of these topics, but rather is an issue paper providing a broad-brush overview. The emphasis, particularly in the initial topic areas, is based on Australian experience, while also commenting on points made in an international context where appropriate.

Industry pressures, training and support: How do I know it is of any use to me?

Menzies *et al.* (2011) grouped agricultural products and services into three broad categories based on a continuum from scientifically proven concepts at the one extreme (*e.g.* symbiotic rhizobial nitrogen fixation by legumes) through to concepts totally unsupported by any shred of scientific evidence at the other and which exist solely through the blind faith of their proponents (*e.g.* homeopathy). Between these two clear extremes, decision-making becomes more difficult where scientific investigations are limited (hence there is little useful information), where the results of investigations appear to be inconsistent, or where results are being mis-quoted or being used to support product use in a different (non-proven) context. The waters here are also increasingly being muddied by pseudo-science that sounds plausible but attempts to re-write basic scientific principles to its own end (see Edmeades 2011).

While the extremes are clear, at least from a scientific viewpoint, the middle ground requires critical analysis by the end user or (preferably independent) advice from elsewhere. In Australia, most professional turf managers (superintendents, greenkeepers, curators, parks managers, etc) have received tertiary level training in practical green-keeping through the Technical and Further Education (TAFE) system, but not university training aimed at sharpening their critical analytical capabilities; sod growers, on the other hand, are farmers, usually with little or no tertiary training and limited technical knowledge. For both groups, their job and/or their livelihood depends their being able to achieve a high quality product at an acceptable cost/price. This situation leaves them vulnerable to someone with a product to sell and a good story to tell, particularly if and when something goes wrong with the turf on their facility or farm. (The number of university-trained turf managers in the US is far higher than in Australia, but this still does not always lead to better critical analysis of technical issues, particularly when their job might be on the line). This situation is further compromised by the strategic sponsorship of events and organisations by enterprising product distributors who tend to employ ex-greenkeepers or ex-superintendents.

The availability of competent independent technical advice in Australia is extremely limited. Excluding ex-greenkeepers and similarly trained persons, there are very few independent consultants who have received proper technological training and are experienced in turf agronomy and underlying soil issues. The industry-supported Australian Turf Research Institute (ATRI) was a source of independent research and technical advice from

1964 through to its closure in the late 1990s. Nowadays, the only industry-funded support of this kind is a single agronomist employed by the Australian Golf Superintendents Association to service the whole of the Australian golf industry.

Based on Queensland economic data from the state Department of Agriculture, Fisheries and Forestry (DAFFQ 2012), the non-edible (lifestyle) horticulture sector – ornamentals, turf and flowers - contributes approximately 10% to the state's farm-gate value of agriculture, making it comparable in value to fruit and to vegetables, but with a greater multiplier effect (4 times) through associated services (DAFFQ 2011). Public support programmes for turf and the overall lifestyle horticulture industry existed in Victoria from the early 1970s through to the early 1990s, and in Queensland from 2000 to 2012; both were summarily closed to meet state government austerity targets. In Australia, the perception and the rhetoric from all who contribute to the debate at state and national levels – politicians, government bureaucrats, as well as farmer and professional peak bodies – is that agriculture, and the future of agriculture, relates only to food and fibre; but while people need to eat and need to be clothed, they also value their lifestyle, making the last associated activity one of our more profitable and rapidly growing primary industries. So while food- and fibre-related industries continue to enjoy considerable technical support and independent advice from government services, the non-edible lifestyle horticulture sector receives essentially nothing. To illustrate the disparity in resource allocation, turf in Queensland - a A$125 million industry (DAFFQ 2012) – now receives no technical support from government while mangoes – a A$70 million industry (DAFFQ 2012) – continues to enjoy the support of approximately 35 staff (S. Holborn, pers. comm.). Limited turf research programmes continue at three Australian universities: Queensland, Western Australia and Sydney.

The legal landscape

Because of the risk of litigation from aggrieved product suppliers, scientists are reluctant to speak out on the value of specific products. Instead, they prefer to comment in more general terms about a concept or a group of like products.

These risks were dramatically illustrated by the celebrated Maxicrop case in New Zealand during the mid-1980s (Menzies *et al.* 2011). In this, the Bell-Booth Group (marketers of Maxicrop, a concentrated seaweed extract) sued the New Zealand Ministry of Agriculture and Fisheries (MAF) and Dr Doug Edmeades (a MAF employee) personally for damages (initially NZ$5.5 million, later amended to NZ$11.5 million). Maxicrop had been promoted as a fertiliser, providing nutrients and plant hormones. The recommended application rates, highly diluted, meant that it was considerably cheaper than conventional fertilisers. After extensively reviewing the world literature on non-traditional fertilisers, analysing Maxicrop, and undertaking field trials with it, Edmeades came to the conclusion that, used as directed, the product could not possibly provide the claimed benefits. In April 1985 Doug Edmeades appeared on the TVNZ program 'Fair Go' with Mark Bell-Booth and David Bellamy in which he presented his case against Maxicrop. This was the basis for subsequent protracted and expensive legal action, which MAF and Edmeades eventually won.

Turf nutrition

Soil testing

How should turf managers and sod growers decide which nutrients and how much of each to apply? In most cases, the basic information required to develop a fertiliser programme will come from soil testing (Loch *et al*. 2010). Soil testing, however, is a "garbage in – garbage out" process: if a representative soil sample is not taken, if the methodology used has not been calibrated against extensive fertiliser trials in that region, and if reliable sufficiency levels (by which fertiliser requirements can be objectively and independently assessed) have not been properly correlated with response data, then the results and recommendations may be worthless. In the Australian turf industry, the majority of soil testing (estimated at about 70%) is conducted through product supply companies using their own proprietary analysis and reporting systems, principally as a means of supporting product sales. In this context, the widespread use of Mehlich 3 (developed in the US for US soils) as a universal extractant for several nutrients offers economies for proprietary soil testing systems, but first needs to be properly calibrated as described above and sufficiency levels developed for Australian soils. A start on this has been made in Western Australia using historic soil samples from earlier fertiliser trials (Bolland et al. 2003), but this is no longer possible in other states (*e.g.* Queensland – DE Baker, pers. comm.) where the necessary historic samples have been discarded. Worse, some commercial providers have lengthened the extraction time with Mehlich 3, effectively creating another new method for which there is currently no calibration whatsoever.

Interpretation of soil test results: Base Saturation Ratios vs. sufficiency levels

Soil concentrations of Ca, Mg, and K are interpreted by one of two different methods: the sufficiency level of available nutrients (SLAN) and the Base Cation Saturation Ratio (BCSR), with the latter still widely used throughout the turf industry (Loch 2006). The term "base saturation" describes the degree to which the available exchange sites in the soil are occupied by the basic cations (*i.e*. Ca, Mg, K, Na), hence the BCSR concept promoted by some laboratories and agronomists as a way of maintaining an "ideal" balance of cations on the exchange complex. This concept was proposed by Bear *et al.* (1945) and later continued by Dr William Albrecht (*e.g.* Albrecht 1975), based on their work with fertile soils in north-eastern USA. In the so-called Albrecht Method, nutrients are applied in sufficient quantities to maintain, or bring the soil back into, an "ideal" balance of cations, though the preferred ranges specified for the percentage of each cation do vary among proponents of the Albrecht Method (Table 1).

Basing fertiliser recommendations on the percentages of different cations on the exchange complex is attractive to commercial laboratories because it does not require

Table 1. "Ideal" cation percentages on the exchange complex as proposed by various sources.

Cation	Bear *et al.* (1945)	Graham (1959)	Albrecht (1975)	Baker and Amacher (1981)	Ninemire Labs.
Ca^{++}	65	65-85	60-75	60-80	68-72
Mg^{++}	10	6-12	10-20	10-20	13-16
K^{+}	5	2-5	2-5	2-5	3-5
Na^{+}			0.5-5		<3
H^{+}	20		10		4.5
Other cations			5		5

extensive research to calibrate the methodology on which their recommendations will be based. However, it is a soil-based concept that ignores plant requirements (indicated by sufficiency levels) and does not take account of differences between species in their adaptation to differ-ent soil conditions. Essentially, it is a case of "one size fits all" - both plants and soils. Albrecht-based recommend-ations for calcium (Ca), magnesium (Mg), and potassium (K) fertilisers are generally higher than if based on achieving sufficiency levels for each nutrient. For example: soils with >2.0 meq% of Ca and Mg will generally have sufficient levels of these two elements for plant growth. Typical examples of Albrecht-based recommendations are: (1) to fertilise to bring a particular cation up to a certain percentage on the CEC sites; (2) to raise the percent base saturation of that cation to some designated value; or (3) to adjust to a particular ratio between cations.

Over the years, numerous scientists have questioned the usefulness and validity of the Albrecht approach, most recently Kopittke and Menzies (2007) who reported fundamental flaws in several of Albrecht's experiments. Wide variations in percent CEC saturation for each cation (other than sodium) and the ratios between cations have been reported, and these differences do not correlate well with plant response. There is little evidence for "ideal" cation ratios or for a percent base saturation level (*e.g.* 65-85% for Ca) as being "ideal"; and in low exchange capacity soils, raising the base saturation percentage for Ca into this range can lead to an excessively high soil pH. Furthermore, it was recognised more than 100 years ago (Veitch 1904) that acid soils are aluminium saturated, rather than H^+ saturated (a state that can never occur in reality). The fact that Albrecht proponents continue to report H^+ levels only serves to emphasise that this is based on inappropriate (and very out-of-date) analytical approaches. As summed up by Haby *et al.* (1990) in their review of soil testing methodology in the USA:

"Numerous experiments over the past [60+] years ... have demonstrated that the use of the [Albrecht] approach alone for making fertilizer recommendations is both scientifically and economically questionable".

Tissue testing

Soil and plant analysis meet different needs for the turf manager (Loch 2006). When properly used they comple-ment one another in terms of the information provided. Plant tissue analysis gives a much more direct measure of what the plant is using; the procedures are universally applicable (in contrast to soil testing methodology); and regular plant tissue testing enables plant nutrient status to be monitored. However, the interpretation of plant analysis data for turfgrasses is not always straight forward. At present, the greatest problem with being able to use plant tissue analysis routinely is that reliable interpretive data are lacking for most of the warm-season turf species and cultivars used in Australia. Relevant criteria still need to be developed through future experiments.

Nitrogen (N)

Nitrogen is the main driver of grass growth. This is strikingly illustrated by results from the long-term Rothamsted Park Grass Experiment in which plots have been fertilised annually with N (from different sources and at various rates) and other nutrients including P and K since 1856 (Silvertown *et al.* 2006; Woods and Rossi 2011). Sub-plots within the main plots are then limed to maintain a range of pH levels. The N-only plots are grass dominant with very few broadleaf species. P, K and lime have all increased the incidence of broadleaf species (*e.g.* weeds like dandelion). That raises two obvious questions: how much P and K are used on turf; and how much do we really need?

Phosphorus (P)

A recent survey of US golf courses by Throssell *et al.* (2009) found that superintendents use 35 kg P/ha annually across 457,710 ha. This is equivalent to a rate of almost 400 kg superphosphate per ha. While this is clearly excessive and wasteful, it also runs the risk of causing environmental damage through nutrient loss into water-ways, which consideration is now leading to restrictions on fertiliser use in some states of the US.

Grasses in general need only quite low levels of P to maintain healthy growth. For example, Hull (2005) reported that soil P sufficiency levels for the maintenance of *Agrostis stolonifera* (creeping bentgrass) and *Cynodon* spp. (bermudagrasses) in a sandy soil rootzone were 10-15 ppm P and <10 ppm P, respectively, as measured by a Bray 2 test. An old rule-of-thumb by Australian pasture agronomists is that grasses need 10-15 ppm P (on a Colwell or Olsen test) while most legumes need >30 ppm P. A high level of leguminous weeds in turf is therefore a good visual indicator of P overuse.

The use of additional P in starter fertilisers during turf establishment is a widely promoted and well-established industry practice, apparently based on extrapolation from the needs of crop plants other than grasses. Contrary to this belief, experimental work by Loch and Zhou (2013) showed that adding additional P to newly-laid sod of *Zoysia japonica* and *Z. matrella* (zoysiagrasses) risked creating toxicity at relatively low P levels, which reduced the development of new roots in particular – the exact opposite of what is required during the establishment of a new turf construction. While the *Zoysia* species are known as low fertility grasses, this work now needs to be repeated to see the effect of added P on medium and high fertility turf species during establishment.

Potassium (K)

Potassium is second only to N in terms of the quantity used to fertilise turfgrass areas. In large part, this stems from a widely held belief among turf managers that K is beneficial to plant health (or disease resistance), hence its use in particular leading into winter. From their survey of fertiliser use on US golf courses, Throssell *et al.* (2009) reported that 190 kg N/ha was applied annually to 530,555 ha and 107 kg K/ha applied to 509,915 ha, giving a N:K ratio of 2:1.13. In a three-year study in Florida, Snyder and Cisar (2000) found that increasing K fertilisation of *Cynodon dactylon X transvaalensis* (hybrid bermudagrass) on a sand profile did not increase plant growth, quality or health beyond a N:K ratio of 2:1. Similarly, in a later study, Cisar *et al.* (2013) reported few K responses of note at fertiliser rates exceeding 12.5 kg K/ha/month. Despite this, fertiliser recommendations for *Cynodon* spp. on golf courses in the southern USA still often include amounts of K equal to, or exceeding that, of N (*e.g.* Foy 2000; Baird 2007), and N:K ratios can be as high as 1:5 (JL Cisar, pers. comm..). In Australia, curators of some elite sportsfields are known to use N:K ratios of 1:1 or higher (DS Loch, unpubl. data).

Calcium (Ca)

Calcium products are widely promoted in the turf industry, particularly by proponents of the Albrecht system, with the perceived benefits of improving soil structure and strengthening plant cell walls and membranes. In reality, Ca deficiencies in grasses are rare, so little or no benefit from added Ca is likely on a non-saline soil. Most normal soils contain plenty of Ca, with the greatest risk of low levels and possible deficiency on acid sandy soils (Mikkelsen and Norton 2012; Norton 2013). Each cmol of exchangeable Ca is equivalent to approximately 400 kg/ha to a depth of 15 cm, so that even a soil with a low cation capacity (CEC) could contain several tonnes of exchangeable Ca on cation exchange sites. In this context, it may take large applications of Ca to make significant changes in soil chemistry. Once in the plant, Ca is mostly present in the cell walls and so is not readily mobilised into younger plant parts. This lack of mobility also means that tissue testing may not give reliable results.

On saline soils, Ca plays a major role in correcting ionic imbalances and removing Na from the exchange complex. The principles here are well known and described in considerable detail with examples by Carrow and Duncan (2011). In recent years, products described as soluble (or flowable) gypsum have been marketed for use in both saline and non-saline situations at extremely low rates compared with conventional gypsum. Apart from the fact that these are really finely divided lime in suspension mixed with sulphur (and perhaps a dash of N to show an apparent response), application rates are so low as to have no real effect on a saline soil, delivering as little as one-thousandth of the Ca needed for the required effect. Similarly, they are virtually useless on turf under non-saline conditions, given that additional Ca is rarely, if ever, required.

Biostimulants

In the broadest sense, any material that stimulates life (= bio) could be described as a biostimulant (Karnok 2000). While sometimes marketed as supplying nutrients as well (*e.g.* kelp), biostimulants are promoted as natural products that purportedly improve turfgrass health, vigour and overall quality, especially in turf that is under environmental (drought, heat, cold) or cultural stress. Their unique, sometimes variable and often poorly defined blends of organic and other substances ostensibly supply the turf with necessary substances that are, for some perceived reason, thought to be deficient in the plant or the soil.

Subjective commercial claims of increased drought, heat or cold tolerance are difficult to substantiate; and even when discredited the true believers tend to stick with the unchanged original story. The promoters rely on any published papers that report positive results, regardless of the trial species or the artificiality of the circumstances (*e.g.* root development in hydroponic culture), and ignore any conflicting results. They also fund university and institutional research, the presentation of which not infrequently is less than rigorous, perhaps subconsciously offering some hope to the funder: *e.g.* if a product appeared to work three out of eight times, why did it work on the three occasions and why did it not work on the other five occasions?

Kelp/seaweed extracts

Products based on kelp or seaweed extracts are claimed to improve plant growth through the low levels of nutrients they supply and the undefined plant hormones they contain. In reality, the recommended rates of application are so low that neither of these components has any discernible effect on plants as shown in numerous experiments over a great many years. Yet the love affair that consumers have with such products continues unabated on the basis that they are “natural” or “organic” products (and therefore must be good).

Based on the data used in his successful defence in the Maxicrop case, Edmeades (2002) later published an extensive review of field experiments measuring the effects on crop yields by 28 liquid fertiliser products derived from organic materials. Just over half of these were seaweed extracts, with the others from various sources (fish waste, plants, animals). Statistically, their effects on a wide range of crops were normally distributed around zero, with equal numbers of false positive and false negative responses; this is consistent with probability theory taking into account experimental errors. Essentially, the effects of seaweed extracts (and the other organic products trialled) were no different from applying pure water (see examples in Fig. 1). Edmeades (2002) concluded that none of these products contained sufficient concentrations of plant nutrients, organic matter or plant growth substances to elicit increases in plant growth at recommended rates.

More recently, Loch and Zhou (2013) investigated growth substance effects of a seaweed product applied to

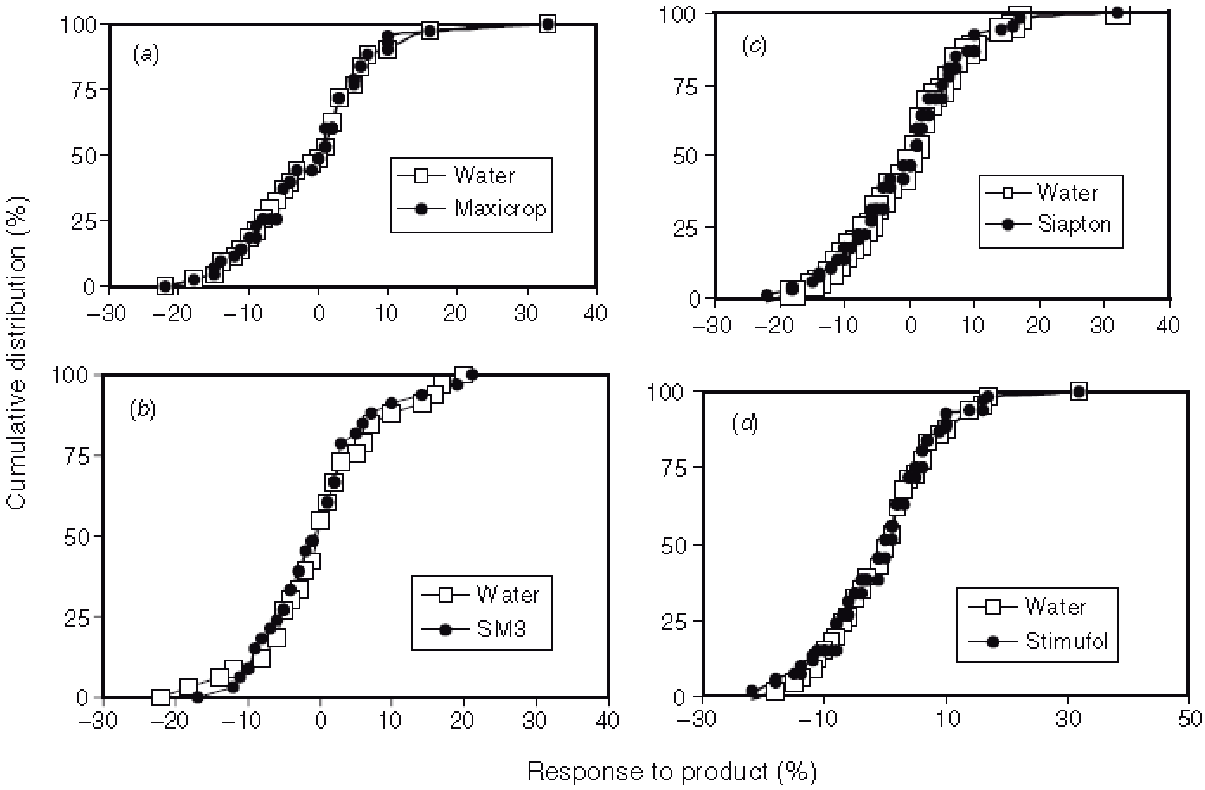

Figure 1. Frequency distributions for Maxicrop (seaweed), Siapton (animal offal extract), SM3 (seaweed), and Stimufol (vegetable) compared with the same application rate of water and expressed as the percentage increase or decrease relative to the control treatment (Edmeades 2002).

newly-laid *Zoysia* spp. sod in three experiments. Even though this was applied as a foliar spray 10 times in the first three weeks after sod laying (applying approx. 750 L/ha – around 100 times the recommended rate of 5-10 L/ha), it had no significant effect – positive or negative - on root development

Humic products

Over the past 10-20 years, humic acid and humates have become a popular fad with turf managers as a result of strong sales promotion, but with little credible technical information, particularly for warm-season grasses. This has largely been extrapolated from work on bentgrasses (*Agrostis* spp.), cool-season grasses being pushed to their high temperature limits on southern US golf courses. Conversely, warm-season grasses are well-adapted to heat, so how relevant and practical is looking for more heat tolerance in this context?

An excellent small book by Billingham (2012) assessed the practical value of humic products for wider agricultural use, and her findings are equally relevant to turf use. If the average Australian agricultural soil already contains 17 t/ha (and even a sandy soil 5 t/ha) of naturally occurring humic substances, why buy and add any more? To put this in context, most application rates range from 5 kg/ha to 1 t/ha for solid products and 1-50 L/ha for liquid products. Moreover, many commercial products are derivatives of brown coal, so hardly of recent natural origin.

Humic products are marketed with a myriad of claims, but little evidence of improved soil properties and plant growth. To make any measurable change in CEC would require a large amount of product (and at what monetary cost). Where excessive amounts of humates were applied to a major Australian sports stadium, this created a soggy organic surface layer in an otherwise well-drained sand profile (DS Loch, unpubl. observ.).

Promotion of humic products relies on published papers that report positive results, regardless of the circumstances of each particular study, while the wider literature continues to reveal contradictory findings, mostly no effect or a negative effect. On sand-based *A. stolonifera* putting greens, for example, Van Dyke *et al.* (2009) reported reduced moisture retention and P uptake, but no effect on chlorophyll content; Mueller and Kussow (2005) found no effect on microbial populations but improvements in visual turf quality attributed to control of localised dry spot which is caused by organic acid coatings on sand particles; and Cooper *et al.* (1998) showed an increase in P uptake but no improvement in rooting (cf. an increase in hydroponic culture). Clearly, this is a topic ripe for an Edmeades-style review of the reported effects.

Microbial supplements

Microbial supplements (or ‘bucket of bugs’) include some quite complex concoctions. However, since healthy soil contains >1 tonne of microorganisms per hectare, first look at what went wrong if the population has become badly depleted before adding a few kilograms of non-native microorganisms from somewhere else. In their study of *Zoysia* spp, establishment, Loch and Zhou (2013) reported that a microbial supplement treatment reduced both root and shoot growth.

Pesticides

Commercial recommendations within the letter of the label can sometimes lead to deleterious consequences: *e.g.*

- dithiopyr – a well-known root pruning herbicide – for use in sod production fields.
- *Trinexapac-ethyl* - Wear tolerance consists of two components: resistance to wear and recovery from wear.
- Trinexapac-ethyl is a well researched growth retardant, restricting turfgrass growth for about 6 weeks after application at normally recommended rates. During that period, it also greatly reduces the rate of recovery from wear, so that intensive use of growth-retarded turf can lead to greater wear damage than on untreated turf, as shown with *Cynodon* spp. (DS Loch and MB Roche, unpubl. data). For this reason, the continuous use of trinexapac-ethyl on turf that is heavily used year-round is questionable.

Ways forward

In the absence of independent technical advice, how do turf managers and sod growers decide whether a new product is worthwhile or worthless?

Warning signs

Develop and maintain a healthy scepticism about commercial claims. Firstly, if a product is not widely used in general agriculture, serious questions should definitely be asked about its efficacy. Secondly, if it sounds too good to be true, it most probably is.

Education

Developing better technical knowledge through education is one obvious way to self-help. For turf managers, this may involve taking university courses, which should also help to sharpen their critical analytical skills. This is important when assessing information from the internet, which includes a lot of misinformation and outright lies as well as good information. Always put greater reliance on peer-reviewed scientific information.

On-site experimentation

For turf managers and farmers, there is the option of testing the product in the field under their conditions (Menzies *et al.* 2011). To test it properly, it needs to be compared with the established alternative, and plots should be replicated (repeated) at least twice, and preferably more times, to ensure that once was not an accident. Look at the results critically, and above all do not fool yourself about what you can see.

Do it right – the first time!

Not infrequently, turf managers resort to alternative products and practices in the hope of correcting a badly designed turf construction where corners were cut. Unfortunately, there are no simple solutions in real life.

Conclusions

The marketing of plausible products with limited or no credible supporting technical data has increased over the past 30-40 years. However, the most expensive product is one that does not deliver any benefits; so, more than ever, turf managers and sod producers need to be vigilant, knowledgeable and discerning in deciding whether or not to use a new product. In most cases, managing turf is a relatively simple business; the basic principles are well known and do not change. However, turf managers fear that their competitors might gain an advantage with new products, the psychology of which is opportunistically exploited and manipulated.

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