Hot Topic: Regenerative Agriculture

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Rationale

These notes have been prepared in an attempt to establish what has already been investigated in New Zealand so that progress can be made in creating what could be New Zealand's Generative Agriculture concept:

> ***Mixed pastures maintained at optimal quality allowing maintenance of high soil organic matter content and the soil organisms it supports by managing grazing animals in a rotation programme which recognises rapid pasture growth in good growing conditions while creating the world's most efficiently produced milk and meat from animals in a natural environment.***

Background

Regenerative Agriculture (RA) focusses on the soil with the general mantra of feeding the soil which feeds the plants and creates nutrient dense food. It also offers increased yields, resilience to climate instability, and higher health and vitality for farming and ranching communities (Terra Genesis International n.d.). Health and vitality are more than nutrient density, the terms also incorporates 'wellbeing'.

Tools used by many (not necessarily all) RA advocates include the Albrecht-Kinsey approach to soil testing, additions of seaweed and fulvates/humate, multi-species pastures and lax grazing (longer intervals and higher residuals than currently advocated in a conventional system) to boost soil health through increasing carbon, Brix to measure feed quality, and reduction in use of synthetic chemicals (including glyphosate and antibiotics, sometimes with use of homeopathic treatments). The involvement of these tools has been identified by tracking links through field days, websites, consultants and their links and qualifications.

RA is not the same thing as organic (RA minimises synthetic inputs whereas organics prohibits them) but has been bracketed with organics by groups such as Greenpeace, Rodale and the Soil Association, and has been welcomed by Organics Aotearoa New Zealand as a 'stepping stone to organic farming…' (OANZ.org n.d.).

RA is receiving considerable attention because proponents are suggesting both that research funding is required to prove its worth and that farmers don't have time to wait for the results. Creating a sense of 'better' and 'urgency' is a classic sales technique designed to create Fear Of Missing Out (FOMO). Proponents have suggested that conventional scientists have created the problem by overlooking the 'whole-systems approach' adopted by RA farmers whilst investigating particular aspects in a reductionist manner. They also suggest that the *'lack of engagement between scientists and regenerative farmers is partly due to (i) the variety of practices are difficult to classify, (ii) the knowledge being context-specific and scattered amongst practitioners; (iii) regenerative management strategies (holistic) being viewed as too complex and time consuming to become mainstream.* (https://soilcrc.com.au/current-projects/#project_4_1_004)'

RA has, however, been described as a system that 'draws from decades of scientific and applied research by the global communities of organic farming, agroecology, Holistic Management, and agroforestry' (Terra Genesis International n.d.). This means that research on organic agriculture can inform the evaluation of regenerative agriculture.

Many of the tools used by RA are common in organic production systems and some have been investigated relatively recently in New Zealand.

Summary

Soil carbon: NZ has a considerable amount of carbon in soil, and 95% of soils are within target range (Schipper et al. 2014, MfE and StatsNZ 2018, Mudge et al. 2019).
Fulvates/humates: NZ soils are full of them as they constitute organic matter (Edmeades 2015)
Compost: limited amounts available in NZ because most animals are not housed. In addition, composting removes nutrients from where the biomass was produced and trying to replace harvested nutrients with compost in a grazing system would result in increased environmental costs

(e.g. greenhouse gases) as well as direct costs (Edmeades 2019).
Seaweed: Maxicrop case – no benefit of seaweed beyond the nutrients added which tend to be extremely diluted (Roberts 2008, Edmeades 2012).
Albrecht-Kinsey: 'continued promotion of the basic cation saturation ratio (BCSR) will result in inefficient use of resources in agriculture and horticulture' (Kopittke & Menzies 2007). No significant differences in yield or nitrate leaching on paired dairy farms over a six year period but the Albrecht-Kinsey approach did result in a more expensive fertiliser regime and a decrease in soil phosphorus (Bryant et al. 2019 funded by SFF MPI).
Long term superphosphate trials: Time is required for changes in fertiliser management (apart from nitrogen) to affect production (Lambert et al. 1998).
Lax grazing: leads to deterioration in pasture quality which will increase GHG per unit of production because of decreased animal performance (Burggraaf et al. 2018 MPI Funded review).
Multi-species pastures: little to no advantage to dry matter production beyond a 3 species mix (Black et al. 2017). More species leads to difficulties in optimising management, competition, death and weed ingress (Tozer et al. 2011) which results in decreased pasture quality.
Brix: no credible evidence for link between brix and pasture growth, ME and hence animal performance (Edmeades 2009).
Low rates of glyphosate: weed resistance is encouraged. Mixing with fulvates (as advocated by Bielski, quoted in MPI 2020) actually decreases the efficacy of the glyphosate (FAR research).
Homeopathy: doesn't work as well as antibiotics (Williamson & Lacy-Hubert 2014).
Yield: Organic production systems are associated with 40% lower yields than conventional systems and there is no evidence that yields increase after the initial drop (e.g. Kirchmann et al. 2016). Lower yield means that environmental impact per unit of food is generally increased (Clark & Tilman 2017).
Nutrient density: when analysed contemporaneously 'the benefits of increased yield to supply food for expanding populations outweigh small nutrient dilution effects addressed by eating the recommended daily servings of vegetables, fruits and whole grains' (Marles 2017).
Resilience and wellbeing: Evidence is scarce that RA confers improved resilience and wellbeing. Overlooked in research that suggests that mixed pastures cope with drought better than conventional pastures (e.g. Weisser 2017) is the opportunity cost of production from species which grow large amounts during the non-drought periods. This has been encapsulated in Francis' (2020) statement that 'the cost of financial stability is foregone profits'.

Wellbeing is subjective. Self-reported data indicating increased wellbeing with RA also indicate increased financial pressure (Ogilvy et al. 2018). The latter was quantified (Francis 2020) at A$246,000 a year foregone.

Explanation

Soil Carbon

New Zealand researchers have been investigating the relationship between soil carbon (C) and pasture management, including the effects of rotational grazing in comparison with set stocking, since the 1940s. Pasture production and soil C in New Zealand have increased over time due to research informing management strategies such as application of fertiliser and lime and optimisation of grazing regimes (Schipper et al. 2017). Soil total C is now within target range for 95% of tested sites (Ministry for the Environment & StatsNZ 2018). Soil C stocks have been estimated as high as 109 and 138 MgC /ha and average approximately 100t C/ha to 30cm depth across New Zealand (Mudge 2019). Once these soils reach higher soil organic C quantities, they can become susceptible to C loss if management and/or climate changes (Schipper et al. 2014).

Sometimes overlooked is that one tonne of C in organic matter is associated with approximately 80-100 kg N, 20 kg P, 14 kg S and smaller quantities of other nutrients (Kirkby et al. 2011). In order to increase soil organic matter through photosynthesis in situ, these nutrients must be supplied and are associated with a cost. Increases in soil C of 8t/ha/yr (Machmuller et al. 2015) have been claimed as a result of adaptive paddock management (rotational grazing) without acknowledgement of the source or cost of the extra nutrients required (e.g. https://agfundernews.com/dr-richard-teague-regenerative-organic-practices-clean-up-the-act-of-agriculture.html and discussed in Rowarth et al. 2020).

New Zealand's challenge is maintaining soil carbon in the face of increasing drought and temperature. Pastures that are fertilised and intensively grazed are able to sequester more soil C than non-fertilised extensively grazed systems, while also producing more food (Allard et al. 2007).

Fulvates/humates

Organic matter comprises fulvates and humates, as well as some soil organisms. The fat that the bulk of the average

100t of C per hectare in NZ soils (to 30cm), which means 1.7t/ha organic matter, is fulvate and humate means that addition of a few kg of either is unlikely to make a substantial difference to activity (Edmeades 2015).

Compost

Replacement of harvested nutrients is possible with addition of compost – 'waste' from harvested material before or after digestion by an animal. The composting process, involving carbon-rich material (such as straw) and nutrient rich material (dung and urine) releases carbon dioxide, methane (under anaerobic conditions) and nitrous oxides, all of which are greenhouse gases (GHG). Compost may also deposit pathogenic bacteria on or in food crops, which has led to more frequent occurrences of food poisoning in the US and elsewhere (Miller & Wager 2020).

Of practical importance is that there is insufficient compost globally to substitute for synthetic fertiliser. Even now, some of the compost used is created with material eliminated by animals which have eaten crop material grown with synthetic nitrogen (Kirchmann et al., 2016). This has been termed 'laundered nitrogen' (Lynas, 2017). Transport and spreading of compost increase both GHG and costs to production. A further factor is that compost depends on moisture and temperature to break down and is vulnerable to wash-off in heavy rain during the decomposition process.

Seaweed

Seaweed has been used as a source of nutrients in many cultures and for many years. It was the subject of the Maxicrop case in the 1980s. Efficacy of additives reflects nutrient content (Horne et al. 2012). AgKnowledge (Edmeades) has several articles in Fertiliser Review on the website explaining the issues.

Albrecht-Kinsey

Soil testing is under debate because some advocates of regenerative agriculture support the approach of Albrecht-Kinsey, which involves adjusting the ratio of calcium, magnesium and potassium to 'feed the soil and let the soil feed the plants'. Lack of research evidence to support this approach has led to the suggestion that 'continued promotion of the basic cation saturation ratio (BCSR) will result in inefficient use of resources in agriculture and horticulture' (Kopittke & Menzies 2007). In contrast, considerable work by New Zealand soil scientists has developed a soil-testing system suited to our relatively recent soils and confirmed the 'overcoming limitations' approach for plant yield which formed the foundation of the MAF Soil Advisory Service. Recent research funded by MPI SFF comparing the Albrecht-Kinsey approach with a conventional (NZ) soil testing over a 6-year period in Canterbury (Bryant et al. 2019) reported that the Albrecht-Kinsey approach resulted in no significant differences in yield or nitrate leaching on paired dairy farms but did result in a more expensive fertiliser regime and a decrease in soil phosphorus. Reviews of the Albrecht-Kinsey system and appropriateness to New Zealand are available (Edmeades 2011, 2015).

Long Term Superphosphate Trials

In the 1990s MAF investigated the effects of withholding superphosphate fertiliser. Effects were not seen for 3-7 years, depending upon the starting Olsen (Lambert et al. 1998). This fits with research using the Hurley Pasture process-based model (Parsons et al. 2016) and that from Germany on the Jena trial (Weisser et al. 2017). Of importance is that initial changes are not always indicative of the steady state that will be achieved: if drystock replace dairy cows, for instance, or lower N input is adopted on a milking platform, organic matter will be broken down with a consequent increase in N leaching (Parsons et al. 2016).

Lax grazing of multi-species pastures

RA means allowing the pasture to grow longer (> 4 leaves in comparison with 2.5-3 leaf stage) and leaving higher residuals than the 1500-1600 kg/ha New Zealand research recommends (DairyNZ 2010). The results are decreases in pasture quality and efficiency of production (Burggraaf et al. 2018 and refs therein). Although increased litter will increase soil organic matter initially, a decrease in N inputs will lead to SOM loss with time. Methane is also affected, increasing per unit of production if animals are not performing at genetic potential (as an increased proportion of energy goes to maintenance). N loss and GHG per unit of milk or meat (time to reach 'weight' is increased) produced will be increased under this scenario in comparison with the current New Zealand system; this means more impact on the environment for a given amount of production (Parsons et al. 2016).

Effects are similar for multi-species pastures due to the increased difficulty of grazing all species optimally. Further, under infrequent defoliation, erect species such as grasses are able to grow taller and thus shade and suppress more prostrate species such as clovers (Burggraaf et al. 2018). This interspecies competition can result in weed ingress which decreases pasture quality (Tozer et al. 2011). Research at Lincoln University under dryland sheep management (Black et al. 2017) examined pasture species mix (19 combinations of four species chosen following earlier research cited in the paper). A balance of three species was identified as optimal for production.

Although other research has indicated more than three species is optimal, Black et al. (2017) explained that without pairwise monoculture comparisons as in their research, it is difficult to assess results with respect to diversity effects. This caveat can be applied to the Jena experiment in Germany (Weisser et al. 2017). Although many measures of ecosystem functioning were not saturating at a mix of 60 species, in the initial years of the experiment biomass increased significantly between monocultures and two species, and then only marginally for the rest of the mixtures (up to nine species). With time there was an increase in biomass with increasing species and species changed: legumes reduced and herbs increased within the sward. This has also been reported to occur in a transition to organic pastures (Schwendel et al. 2015) but is not associated with increased forage quality. Note that the Jena trial did not involve grazing animals.

Current pasture mixes in New Zealand are based on a grass, legume and at least one forb – both chicory and plantain are common in pasture mixes and with time other species appear, not all of which are productive, leading to pasture renewal (often involving undersowing to minimise pasture disturbance). The variety of pasture plants used in New Zealand and their establishment is covered in Stewart et al. (2014).

Brix

In 2014, a contract was awarded to John King (Canterbury) for an SFF project on Brix and pasture energy. The MPI website reveals no further information.

Brix measures refractive index of a solution and is generally used to estimate the concentration of sucrose and other optically active substances. It is only one of the components in a cascade of energy storing materials in plant tissue. Further, in most plant tissues it is only a small part of the total fermentable carbohydrate. Sucrose concentration is related to the relative rates of synthesis and utilisation, which means that it varies during the day and year. Sucrose is approximately 2.5% of DM when swards are fully irrigated but can increase to 12.5% under drought – but forage dietary value decreases during drought. Measuring only on small pool of carbohydrates means that Brix cannot be used to predict pasture quality and hence animal production (Edmeades 2009).

Low rates of glyphosate

Using reduced glyphosate concentration to assist with establishment of new species was mentioned in the 'case study' of the Bielski's in MPI's document 'Fit for a better world'. This practice could lead to weed resistance (FAR n.d.).

Increased yield

Organic production systems are associated with 40% lower yields than conventional systems in developed countries; in some cases, such as potatoes, the reduction can be 100% due to fungal attack (e.g. Kirchmann et al. 2016). Authors could find no evidence to support the contention that organic yields would pick up after the initial decrease reflecting a change.

A meta-analysis of global research supported that organic production systems produce less than conventional systems which means that environmental impact per unit of food is generally increased (Clark & Tilman 2017).

Nutrient Density

The USDA (Department of Agriculture) analysis comparing 'Changes in USDA Food Composition Data for 43 Garden Crops, 1950 to 1999' concluded that 'any real declines are generally most easily explained by changes in cultivated varieties… in which there may be trade-offs between yield and nutrient content' (Davis et al. 2004). An update (Davis 2009) indicated the existence of genetic dilution effects, that is where yield increases come from selective breeding rather than environmental measures such as fertilization.

Archived samples have shown that soil mineral composition had not declined 'in locations cultivated intensively with various fertilizer treatments' (Marles 2017). Most historical reports have not accounted for 'changes in data sources, crop varieties, geographic origin, ripeness, sample size, sampling methods, laboratory analysis and statistical treatment'. By doing the analyses contemporaneously, Marles (2017) was able to conclude that 'the benefits of increased yield to supply food for expanding populations outweigh small nutrient dilution effects addressed by eating the recommended daily servings of vegetables, fruits and whole grains'.

In the same vein, a meta-analysis of 237 studies to determine whether organic foods are 'healthier' than non-organic foods concluded that 'fruits and vegetables that met the criteria for 'organic' were on average no more nutritious than their far cheaper conventional counterparts'(Smith-Spangler et al. 2012) .

Homeopathy

Considerable research, including by DairyNZ (Williamson & Lacy-Hubert 2014), has shown that homeopathic treatments in cows is almost as effective as letting the health issue resolve on its own.

Resilience and wellbeing

Resilience of pasture due to inclusion of multi-species has been linked to regenerative agriculture, and was a factor investigated in the Jena experiment in Germany (Weisser et al. 2017). Resistance (the degree of change after perturbation) and resilience (time until pre-perturbation state is regained) of aboveground biomass production against drought were found to be highly dependent on management intensity and only partly on species richness (Weisser et al. 2017). This has implications for grazing management which is an important factor in pasture persistence (Tozer et al. 2011).

Australian research (Ogilvy et al. 2018) involving 14 best practice regenerative graziers (BPRG) indicated that they experienced a meaningful and significant wellbeing advantage compared with conventional NSW farmers (51) matched for gender (male) and age (40-60). The major factor driving the increase was 'health' which might have been skewed by small sample size. Other factors in the increased wellbeing, and included in increased 'resilience', were higher 'farming self-efficacy' (confidence in being able to manage different aspects of their farm successfully) and financial stability. However, the BPRGs also reported higher financial stress – over 21% of the BPRGs were under financial stress in comparison with under 14% of conventional farmers (which could be presented as 50% more under financial stress, thereby revealing the importance of knowing the starting point for any comparison). Francis (2020) interpreted the cost of financial stability as 'foregone profits'. Re-analysing the Ogilvy data, Francis (2020) concluded that the regenerative graziers Return on Assets Managed (ROAM) was 1.66% in comparison with 4.22% for conventional graziers, and that the average cost per farm of being regenerative over the decade studied was A$2.46 million. Francis also concluded that the regenerative agriculture systems in the Ogilvy study 'must have been significantly less productive' than the conventional systems.

Ogilvy et al. (2018) acknowledged that 'the sample of graziers was small and the lack of data about the ecological characteristics of the broader population of graziers in the grassy woodlands biome meant that it was not possible to confirm any causality between the condition of the ecosystem and profitability or with higher wellbeing'. Perhaps of most importance in the research was that the regenerative graziers 'nominated the education and coaching they've received through the holistic planning and related management frameworks as significant influences of their current practice'. The graziers felt supported in doing what they had been encouraged to think was the right thing. The fact that some of the factors in 'right thing' were measured atypically (profit per stock unit rather than per hectare/farm), were not measured (biodiversity), or were self-reported (wellbeing) in a report with the title 'Graziers with better profitability, biodiversity and wellbeing' should give pause for thought.

Conclusions

RA is a holistic approach to food and fibre production where the whole is greater than the sum of parts. This is indicated by the fact that 'reductionist science' cannot embrace the complexities. Despite this, it is clear that considerable research, with specific components within systems in New Zealand, has been done, the results of which indicate that not all of what is being suggested by RA advocates will achieve what is thought.

New Zealand has already achieved a competitive advantage for animal protein which a change to RA could erode. In addition, there is no evidence that RA will achieve the goal articulated in Fit for a Better World (MPI 2020): that regenerative farming systems will improve the profitability of farming while leaving behind a smaller environmental footprint. New Zealand farmers can, however, keep adapting and fine-tuning the system as climate and markets change, supported by research and education.

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