High plant diversity a must for effective cover crops

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Growers wanting to achieve greater soil and productivity improvements from green manure should consider the potential benefits of diversity.

Former SANTFA Executive Officer Alex Milner-Smyth travelled to North and South Dakota, Montana and North Carolina to explore aspects of the management and impacts of diverse cover cropping within cropping systems.

This article outlines some of her observations from that trip.

More detail is available in Alex's trip blog, which can be accessed at www.alexmilnersmyth.wordpress.com

Growers thinking of incorporating cover crops into their rotation should aim for a mix of seven or eight different plant species, whether they plan to seed a warm- season stand after harvest or are sowing a cool-season cover at seeding instead of setting up a year-long fallow.

When I returned from my study tour to the US last year I was asked to speak about my findings at the Agricultural Bureau's annual dinner, which last year also marked the organisation's 125th birthday.

After my presentation, farmers from many parts of the State approached me to tell me of their plans to plant cover on their paddocks directly after harvest.

However, despite my blog posts and presentation promoting the benefits of diversity, almost all of them were intending to plant monocultures of crops such as millet or sorghum.

Multi-species cover crops that mimic naturally-occurring diverse ecosystems are much more stable and productive than manufactured monocultures.

Ecologists have long understood the importance of diversity in ecosystems and conclude that biological communities are more productive (in terms of biomass) and resilient when the number of species is high.

Diverse plant populations use resources such as water and soil nutrients more completely, resulting in increased production. They are also more robust.

The one factor common to the extremely cold and extremely hot environments in which plants and animals survive in some of the most desolate and extreme conditions on the planet is the diversity of plant and animal species in those environments.

Three main ecological phenomena contribute to the success of diverse biological communities.

Complementarity, which can be explained as the whole being greater than the sum of the parts, relates to situations in which the qualities of two or more different species improve the overall system.

Facilitation refers to a plant's ability to influence environmental conditions in a way that helps neighbouring species thrive. Legumes facilitate the growth of non-legumes by fixing nitrogen that becomes available to the other plants.

Tall plants provide shade for emerging seedlings, reducing the exposure to water and temperature stress.

The law of The Sampling Effect states that the greater the diversity in an ecosystem, the greater the chance that a high-yielding species will be present. (The more children in a classroom, the more likely you are to find a Mensa candidate).

Because highly diverse systems have more complex relationships, system output is also more varied. (See Figure 1.)

Diversity in managed situations such as cover crops in cropping systems is important for several reasons, especially where soil regeneration is a primary driver.

Out of sight

A mix of differing root structures impacts on use of the available moisture and nutrient resources and on biological activity in the soil.

Different species have different root characteristics and having roots distributed through the soil profile means moisture and nutrients are accessed from different levels so no one section is depleted. Phacelia, for example, has a fine root network close to the soil surface. Sorghum or lucerne can penetrate heavy clay soils to a depth of more than a metre.

Having roots distributed throughout the soil profile distributes organic matter through more of the soil volume and stimulates soil biological activity by increasing the amount of carbon available to soil organisms. It also provides greater opportunity for the interactions between roots and soil organisms that are critical to nutrient cycling.

When I was in the US in September last year, North Dakota, South Dakota and Montana had all recorded lower than average rainfall and unusually high summer temperatures. Despite these tough conditions, which severely stressed and in some cases killed crop monocultures, the mixed cover crops I saw, some of which included winter species such as oats and wheat, were thriving.

It was thought one of the reasons these diverse stands were so resilient in the hot, dry conditions was because they were able to obtain moisture and nutrients from different zones within the soil. In a monoculture all the plants are competing for moisture and nutrients from the same layer of soil.

On one farm in Montana a father-son 'communication error' led to a winter cover crop mixture being planted in the height of summer. Despite having grown 'out of season', the mix of winter species looked to have produced the same amount of biomass as a summer mix in an adjoining paddock.

Physical attributes

The basic physical attributes of plants have crucial roles in their contribution to the overall efficacy of a mixed cover crop.

Sunflowers and corn are included for their height, which provides shading for smaller species in the mix, and peas and other climbing plants will often use them for support, wrapping around and climbing up their thick vertical stems.

The dense, spreading structure of plants such as vetch provides significant soil shading that contributes significantly to a reduction in soil temperature.

At Menoken Farm, a government-owned trial site in North Dakota, measurements have shown that, at the height of summer, soil under a cover crop can be more than 10°C cooler than soil with no surface cover.

American cover croppers also use the physical attributes of the roots of some plants to achieve soil improvement objectives. One example of this is including root vegetables such as radish or turnip and plants with large taproots,

DIVERSE COVER CROPS AND GREEN MANURES HAVE PLAYED A KEY ROLE IN DEVELOPMENT OF ALMOST 30 CENTIMETRES OF NEW TOPSOIL OVER THE PAST 20 YEARS ON GABE BROWN'S NORTH DAKOTA PROPERTY.

such as sunflowers, specifically to break up compacted soils.

Formulating a cover crop mix to achieve specific desired outcomes enables farmers to simultaneously tackle multiple issues such as sub-soil hard pans, compaction and organic matter increase just by tailoring the seed mix.

Diverse communities

Diverse systems thrive because participants are able to provide (exchange) different services.

Human communities rely on different people performing certain roles. A town with three lawyers but no doctor or teacher would run into trouble when the lawyers become sick or have school-aged children. The same principle applies to plant and soil communities.

The theories of species selection that underpin the American style of cover cropping encourage the use of a few main staples. Flowering plants attract pollinating insects, ground covers provide shade, legumes fix nitrogen and deep-rooted plants including root vegetables break up compaction.

Livestock benefits

A diverse cover crop offers another level of benefits for growers running livestock. Variety in feed crops offers a more balanced diet to stock through provision of a greater variety and better balance of nutrients.

Many cover-cropping American farmers reported stock 'self-medicating' by selecting specific plants from within a cover crop. Several told me that cattle would pull root vegetables out of the ground and eat them once stocks of higher-level ground cover had been depleted.

North Dakota farmer Gabe Brown reported a significant reduction in the prevalence of iodine-deficiency symptoms such as eye infections in his cattle following the introduction of diverse cover crops.

Gabe also thinks that using stock to graze cover crops accelerates the regeneration of depleted soils. He attributes this to the return of nutrients in the animals' manure, plant desiccation as a result of stock trampling and through the application of stock saliva during grazing, which potentially contributes towards the break-down of residual biomass.

DIVERSITY IN ROOT AND PLANT FORM HAS A VITAL ROLE IN MODIFYING ABOVE-GROUND GROWING CONDITIONS FOR PLANTS IN COVER CROP MIXTURES AND SOIL CONDITIONS BELOW THE SURFACE.

Food for thought

Based on the US experience, there are some simple guidelines for growers interested in achieving a diverse year-round ground cover.

Gabe Brown's advice to new cover croppers is to 'keep the acres low and the diversity high'. This allows a cost-managed approach to experimenting.

USDA Soil Conservationist Jay Fuhrer, who has worked extensively with growers to adapt initial cover crop 'recipes' to improve the performance and increase the benefits of cover crops, says time of sowing is critical and it is important not to be impatient. To get the full benefit from a cover crop it is important to give the plants in the mixture time to develop and thrive before the stand is terminated.

Winter species can thrive in summer cover crops when there is adequate ground cover to reduce soil temperature, so designed cover crop 'cocktails' can be supplemented with seed on hand to reduce initial costs.

Growers wondering about the suitability of the diversity approach in their conditions should consider comparing the performance of the diverse mixture with the performance of monocultures of the species in the cover crop mixture. This can be achieved by sowing strips of the individual species used in the mixture beside an area of the multi-species mixture.

Assessing the benefit

Monitoring the efficacy of cover crops presents significant challenges. Not only may the effects of cover cropping not be

evident in the first few years; the reasons for success or failure of the system, or individual cover crops, may be hard to identify. However, seasonal 'before' and 'after' soil tests will provide valuable data on the impact of year-round cover on basic soil elements and organic matter levels, and harvest-time yield monitoring can track yield trends in cash crops.

Weed numbers, the need for herbicide and fertiliser applications, erosion, soil temperature and soil moisture levels, soil organic matter (carbon) content and cash-crop yields in the years following a cover crop all need to be considered when determining whether a mixed cover crop has been successful.

A cover crop dense enough to suppress weeds sufficiently to eliminate the need for a herbicide application will provide a direct and immediate financial benefit and reduce the selection pressure for herbicide resistance, although this risk reduction is hard to quantify financially.

Growers should also take account of physical benefits such as reduced soil erosion, increased water holding capacity and increased root depth of cash crops. Soil water levels can be measured using moisture probes. Alternatively, using the French-Schulz model or an equivalent to calculate the water use efficiency of cash crops planted after cover crops will provide an indication of the effect of cover cropping on water and nutrient availability.

Grazing

Cover crops can be grazed, so long as the species included in the mix are safe for stock.

American farmers have two general rules for grazing cover crops:

- use big mobs on small areas for short periods. This applies high grazing pressure, which encourages efficient use of the resource, but avoids over-grazing and erosion.
- allow stock to eat only a third of the biomass, with the residual cover retained for soil health.

For more information:

- Listen to the audio files of cover croppers Craig Duffield and Nathan Craig from the 2013 SANTFA Conference, available at: www.santfa.com.au
- Read Alex's blog: www.alexmilnersmyth.wordpress.com
- Have a look at 'Why crop diversity is so important' by The Ecologist founder and essayist Edward Goldsmith, available at: http://www.edwardgoldsmith.org/847/why-crop-diversity-is-so-important/

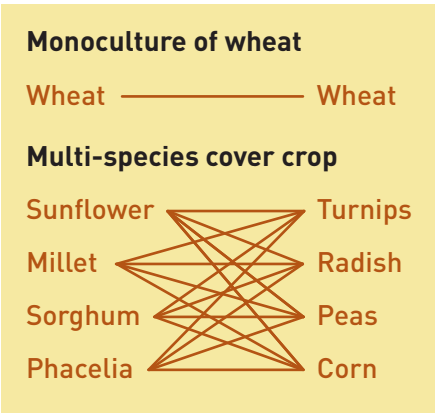

FIGURE 1: MORE DIVERSE SYSTEMS HAVE HIGHER NUMBERS OF INTERACTIONS.

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