Teaming up for good: Intercropping and farming-science partnership

Agroecologist, Pete Iannetta and colleagues from LEAF Innovation Centre, the James Hutton Institute, explain the science behind Intercropping and introduces a new EU funded project, DIVERSify, which aims to connect Farmers with agricultural researchers to help implement intercropping on-farm.

Summary

- Intercropping is a farming practise where multiple crops are grown in close proximity to each other
- This can provide a host of benefits, helping to maximise yield and natural chemical cycling, make the most of soil nutrients and help provide biological pest control.
- The James Hutton Institute along with LEAF and a range of European partners have partnered up on a project called DIVERSify (https://www.plant-teams.eu/) which is keen to hear from farmers who are intercropping or keen to trial it.

Introduction

The concept of growing two or more crops together, in the same space and time, is termed "*intercropping*" by researchers, though the approach may also be characterised by the term "*plant teams*". Whichever is preferred, they both refer to what was a standard practice historically. The use of plant teams is still widespread today, but only among farmers who wish to maximise natural chemical cycling, nutrient use efficiency and biological pest control. That is, users of plant teams aims to maximise productivity whilst minimising, and even avoiding completely, their reliance on external inputs such as inorganic fertilisers and pesticides. Such an aim is admirable, since in today's age farmers are under greater pressure to make their farmed systems more productive as well as improving components such as soil structure and biodiversity, and whilst also staying profitable.

This challenge can be worrying and as the author of the book Soul Searching (Keith Caserta) penned, "*worry is the interest you pay on a debt you may not owe*". Nevertheless, every year farmers respond positively to the gauntlet which history has thrown before them. Recently, this gauntlet has been characterised as "*sustainable intensification*" by farming policy makers. This term is, in fact, an oxymoron, and approaches to maximise outputs whilst minimising inputs should rather be termed "*sustainable deintensification*", which is more scientifically accurate. Placing such contextual and philosophical considerations aside and to re-focus on farming practice, there are many agronomic measures which may be used to increase efficiency and yet while the use of *plant teams* is among the most promising of methods, it does not feature strongly as common practice in the UK. There are many reasons for that, but first let us look at the research findings which aim to understand why *plant teams* work, and provide examples of results from agronomic studies.

Benefits of Intercropping

Plant teams are usually deployed by organic farmers and proponents of conservation agriculture. One of the more common types of *plant team* comprises legume and non-legume species. The interplay here exploits the capacity of the legume to meet its own nitrogen requirements *via* biological nitrogen fixation, or BNF. BNF is a natural symbiotic process whereby soil bacteria, referred to collectively as rhizobia, infect legume roots and become entrapped within the core of legume root nodules. In exchange for plant sugars, the rhizobia fix atmospheric nitrogen in biologically useful forms which usually starts with the synthesis of ammonia. BNF can be highly efficient and for example, experiments within the Balruddery Farm

Centre for Sustainable Cropping at the James Hutton Institute have shown that faba bean crops can fix up to 300 kg of nitrogen, with up to 100 kg being left in-field in residues after harvest. In a *plant team*, BNF by legume-rhizobia association is enhanced as a function of the capacity of the non-legume companion plants to compete for, and so deplete, available soil nitrogen.
Such positive plant-plant interactions are allied to other *facilitative* processes. For example, the bacteria which live around the roots of plants (rhizobacteria) are a complex population of species, or *microbiome,* that serve important functions. A well balanced microbiome can help optimise crop fitness. In 2016, it was found that the rhizobacteria community of the legume species *Lotus japonicus* L., a model species for researchers, harbours a high density of symbiotic or plant growth promoting microbes. Such microbes may exhibit traits such as BNF, although they cannot nodulate legumes, and they show other attributes such as a high efficiency to suppress soil-borne pathogens, increase the bioavailability of soil phosphorous and even extend to the secretion of IAA (indole acetic acid), a plant growth hormone.

Thus, a non-legume co-existing with a legume does not simply benefit from the legumes capacity to entrap rhizobia for BNF within root nodules, but also form a "*symbiotic microbiome*" that extends into the soil rhizosphere. Furthermore, such facilitative traits are not simply a feature of legume species, and cultivating different species of non-legumes and even distinct varieties of the same species have shown excellent results for plant productivity. This has been proven by many years of research within the James Hutton Institute showing that growing different varieties of cereals together is a proven method of biological disease control, which can justify reductions in pesticide use.

New Opportunities

The science literature on agronomy for *plant teams* shows clear benefits: a study of legume supported crop rotations throughout Europe showed that productivity peaked when legume inclusion was 50% in the rotation, with an equal balance of forage and grain legumes, often deployed in a *plant team*. Such positive findings are realised despite the fact that the modern crop (non-legume) varieties are bred for high input monocropping, and so are unlikely to exhibit traits for optimal performance for co-existence with a companion species. Modern day breeding programmes have mainly selected for yield and disease resistance attributes. Thus, the development of agronomic and breeding approaches to optimise the function of, and the agronomy for, *plant teams* is in its infancy and takes the form of EU funded industry-science partnerships *via* projects such as *DIVERSify (www.plant-teams.eu) and TRUE (www.true-project.eu)*. Such research and development efforts aim to realise economic strategies that are better harmonised with parallel policies targeted to safeguard environmental *and* human well-being.

Projects funded by governments within the UK include for example those focussing on barley-pea intercrops, and crop products for brewing and distilling. Of the Scottish arable area (1,900k ha in 2014), 55% was sown with barley, of which 84% (874 ha) was spring barley - the main raw material of the brewing and distilling industries which are of critical economic importance to the UK, contributing almost equally to the £10 billion annual UK tax revenues. Spring barley normally requires 110 kg of inorganic nitrogen fertiliser *per* hectare. This nitrogen requirement could be provided exclusively by *plant teams*. If achieved for the spring barley area (in Scotland), the carbon footprint (carbon dioxide equivalents (CO_2e) and financial savings would be around 1.36 MT and £27.6 million, respectively. It was also found the barley component of a barley-pea *plant team* sown at a ½ seed rate and without the use of any added mineral nitrogen, pesticides or herbicides, produced high quality yields that were equivalent to that of the barley monocrop sown at half the full seed rate. The barley within the team produced twice as many tillers and the associated grain exhibited a higher level of grain nitrogen than the monocrop (at 1.3% nitrogen), which is a good level for malting for fermentation based processes. Furthermore, the land equivalent ratio, was 1.2, that is 20% more yield than would normally have been achieved with a monocrop, and the pea nitrogen (protein) levels were on average 10% higher, depending on which variety was used.

Similarly, *plant team* based approaches for the production of whole crop forages has proven equally promising, with winter rye, winter oat and winter pea combinations showing high biomass yield, protein and good digestibility and under conditions of reduced (50% nitrogen) inputs. Barley and wheat contribute well to digestibility too and faba beans have potential as an alternative to peas. The winter peas are normally problematic under Scottish conditions but using cereals as a support they grew very successfully. Such combinations sown with ryegrass give a second biomass crop feeding on the nitrogen released from the legume roots after cutting the whole-crop.

Get Involved

As part of the DIVERSify project, the James Hutton Institute and LEAF are keen to hear from farmers who are already using *plant teams*, or interested in trialling *plant teams*, such as cereal-legume mixtures. Please email Laura.Tippin@leafuk.org if you are interested in getting involved.
The DIVERSify project is aware that there are many innovative farmers throughout the UK who are advancing agronomic practices using *plant teams*. Such contact is being pursued with a view to understanding farmers' experiences of using *plant teams*, and whether these were successful or not. Also, any general comments or opinions that farmers may wish to make on the use of *plant teams* - since research is not the sole realm of specifically paid researchers but is in fact 'organised curiosity', and a defining behaviour of many farmers.

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