Grain Intercropping

An Introductory Grower Guide

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Thank you to the Wood Family for generously sharing their story

Intercropping can be implemented in a range of different ways, but the core of the practice is growing two or more crops together in the same field at the same time, with at least some part of their life cycles overlapping.

Mostly the crops are sown and harvested together unless their planting and harvesting dates are staggered, which is known as 'relay intercropping'.

Intercropping is different to companion cropping, where two or more plants are grown together, but only one main cash crop is taken through to harvest, with the companion being terminated at some point during the season.

Despite the greater complexity that comes with managing intercrops, the practice has been gaining significant traction in recent years as growers in many parts of the world have discovered the multiple benefits it can bring.

Australian research trials have shown yield benefits from intercropping, with less land required to grow the same amount of grain as monocultures.1

PROS	CONS
Collaboration between plant species can lead to overyielding	Competitive interactions can reduce yield
Reduced inputs required	Agronomic complexities - rotations, seeding and crop management, herbicides and pesticides
Less disease, pests & weeds often observed	Harvest and separation
Less lodging and improved harvestability	Contaminants can limit market access (pea chips, gluten free, etc.)
More species diversity lowers risk of crop losses	
Improved above and below-ground diversity	

THE BOTTOM LINE

Economics & Risk Management

Although over-yielding is observed with intercropping, the more common driver of increased profitability is savings on input costs. Intercrops, particularly with legumes, demand less N and P fertilisers; while lower disease, insect and weed pressure in these diversified cropping systems can lead to significant savings on often-expensive plant protection products.

Even when tonnage yield is not increased, intercropping with higher-value specialty grains can improve profitability. An economic analysis by the Grains Research & Development Corporation in Oat/Lupin intercrop trials showed gross return was $191/ha greater in the intercrop. Economic advantage will be greatest when the two crops have similar prices and large amounts of over-yielding.

Intercrops can help to reduce the economic risk from annual price variability, as well as yield risk.

Diversity provided by intercropping can also reduce risk against adverse events such as frost or drought and can also even out variability in soil type or topography.

For example, farmers in other parts of the world have observed that one of the intercrops thrives in hotter years or ‘high spots’ while the other thrives in cooler years or ‘low spots’ of the field. Equally, one of the intercrops might fare worse after a frost or hailstorm, leaving the other to fill the void and improve the per-field yield compared to a sole crop which would otherwise suffer much greater losses.

Canola and Arrowleaf Clover Intercropping for healthy soil, livestock and resilience

Grower Insights
Wood Family, Central West NSW

Grant and Carmen, Luke and Belinda, Alex and Kate Wood have 1,740ha of cropping and grazing, with wheat, barley, oats, canola, chickpeas, sorghum, and Angus cows, Merino and 1st cross ewes.

Luke's main motivation for intercropping is to build resilience into their farming system, by improving ground cover and drought resistance whilst reducing the impact of volatile input prices and supply chain disruptions on their business. Improved soil health is also a key motivation, with Luke observing more friable soil with increased porosity, aggregation, biology and darker colour.

Luke also feels that the diversity of forage with an intercrop improves livestock health, with less issues associated with grazing solely canola. Additionally, the lower C:N ratio of the clover residues improves overall digestibility.

Luke's expectation is not to grow two full-yielding crops in one paddock in one year, describing intercropping as:

"Not 1+1= 2, but more like 0.5 + 0.5 = 1.3".

"Intercropping adds another dynamic to the paddock - you have to think about things more - it's like having two kids instead of one. You get double the joy when it works. It makes it more interesting than growing a mono."

"It's more challenging than harvesting a straight canola crop, but it didn't turn us off it. We were struggling to find a profitable legume in our system. So If we can grow a legume like this, where it doesn't affect our canola, and we still get the nitrogen benefits and the rotational benefits of having the legume in the system, we'll keep doing it."

Luke Wood

Financial analysis of Canola and Arrowleaf Clover Intercropping, Central West NSW

YIELDS	Canola and Arrowleaf Clover 2021	$/ha	Canola Monocrop 2021	$/ha
Canola Grain Yield	2t @ $800/t = $1600	$1600	2.8t @ $800/t = 2240	$2240
Clover Grain Yield	0.4t @ $2600/t = $1040	$1040		Nil
Grazing	200 Merino Lambs: 6 Wks 1.05 Kg/ Wk 210Kg X 6= 1260Kg X 0.48 X $8 =$4,838/ 30ha	$161		
Residual Nitrogen (from legume rotation intercrop, for 2022 wheat crop)	6 kg post harvest N (0-30cm soil test post harvest) + 50 kg mineralised over summer (assuming 25 kg per T of legume biomass, conservatively) @ $7 per kg plant available N (Urea @ $1610/T & 46%N at 50% N efficiency)	$392		Nil
Soil Health Benefits	Structure, tilth, infiltration, microbial biome diversity, disease suppression not assessed. However, some literature suggests these are impact areas.			
TOTAL VALUE		**$3032**		**$2240**

COSTS	Canola and Arrowleaf Clover 2021	$/ha	Canola Monocrop 2021	$/ha
Canola seed	2kg Hyola 970 @ $38/kg (Feb sown)	$76	2kg 45Y93 @ $35/kg (April sown)	$70
Clover seed	3kg Arrowleaf	$7.80	Nil	
Granular Starter Fertiliser	30kg MAP @ $750/t	$45	30kg MAP @ $750/t	$45
Foliar Fertiliser + Traces Urea	50L N-Fol 24 @ $0.90/L	$45	50L N-Fol 24 @ $0.90/L	$45
Summer Sprays (Jan-Apr 2021)	Nil	Nil	80kg Urea @ $680/t	$54.40
Pre-emergent Sprays	1 x Application Gly/2,4-D/Garlon	$41	3 x Application Gly/2,4-D/Garlon	$123
Post-emergent Sprays	Propyzamide	$30	Propyzamide	$30
Fungicide	Clethodim	$20	Clethodim	$20
Insecticide	Infection threshold not reached - no fungicide	Nil	Aviator	$35
Transport	Nil required	Nil	Nil	Nil
Fuel	Nil	Nil	Nil	Nil
Seed Grading	2t @ $12/t = $24, Diesel = $45, Grading @ $40/t = $80		2.8t @ $12/t	$33.60
Header	3Km/Hr - 2.7ha/Hr @$360, Rotor Hr $133		Diesel	$55
			Nil	
			4Km/Hr- 3.6ha/Hr @$360/Rotor Hr	$100
Spraying	2 x Applications @ $8	$16	5 x Applications @ $8	$40
Sowing		$40		$40
TOTAL COSTS		**$602.80**		**$691**
TOTAL PROFIT		**$2429.20**		**$1549**

NATURE'S FREE INPUTS

Building Soil Carbon

Intercropping can increase soil carbon by increasing the biomass of both plants, with the two species working in a complementary way to use resources at different times and from different parts of the rhizosphere (roots and soil).

Legumes provide the greatest potential to increase soil carbon from intercropping. Legume-based systems can store 30% higher soil organic carbon (SOC) when compared to other species; this is because legumes fix more nitrogen (N) which in turn contributes to carbon (C) sequestration.2 This is achieved primarily via two interconnected pathways:

Firstly, because the biological fixation of N leads to increased plant growth, this assimilates more CO_2 from the atmosphere into plant biomass as C through the process of photosynthesis. When crop residues are broken down, some C returns to the atmosphere as CO_2 and some C is stored in the soil.

Secondly, legumes have biomass and root exudates with a lower Carbon to Nitrogen ratio (C:N), which are more efficiently used by microorganisms, forming more microbial biomass and respiring less CO_2. This microbial biomass is then converted to more stable forms of soil carbon, mainly mineral-associated organic matter. In this way, starting with a lower C:N ratio, such as in legumes, more mineral-associated organic matter can be formed from the same amount of biomass, and this more stable form of carbon stays in the soil for longer.

Including legumes in intercrops can lead to a reduction in the use of synthetic N in subsequent crops due to nitrogen banking (see page 6). Excessive synthetic nitrogen has been shown to be potentially destructive to existing soil carbon stocks.3, 4

Non-legume intercrops also support soil organic carbon (SOC). Research has shown that total root biomass in intercrops was, on average, 23% greater than the average root biomass in sole crops.5

The increased aboveground plant biomass and the below-ground plant biomass, including the increased microbial biomass C within the rhizosphere, can lead to increased C storage in soil. The increase in biomass increases soil organic matter (SOM), which increases soil aggregation. Soil aggregates are where carbon can be protected from microbial degradation, and increasing this stabilisation of carbon is essential to achieve C sequestration.

Intercrop systems that combine a tap-rooting plant with a fibrous rooting plant can also build soil carbon.6 This results in a greater amount of root biomass, and importantly a higher diversity of exudates is left for microbial processing and SOM formation.

Grower Insights

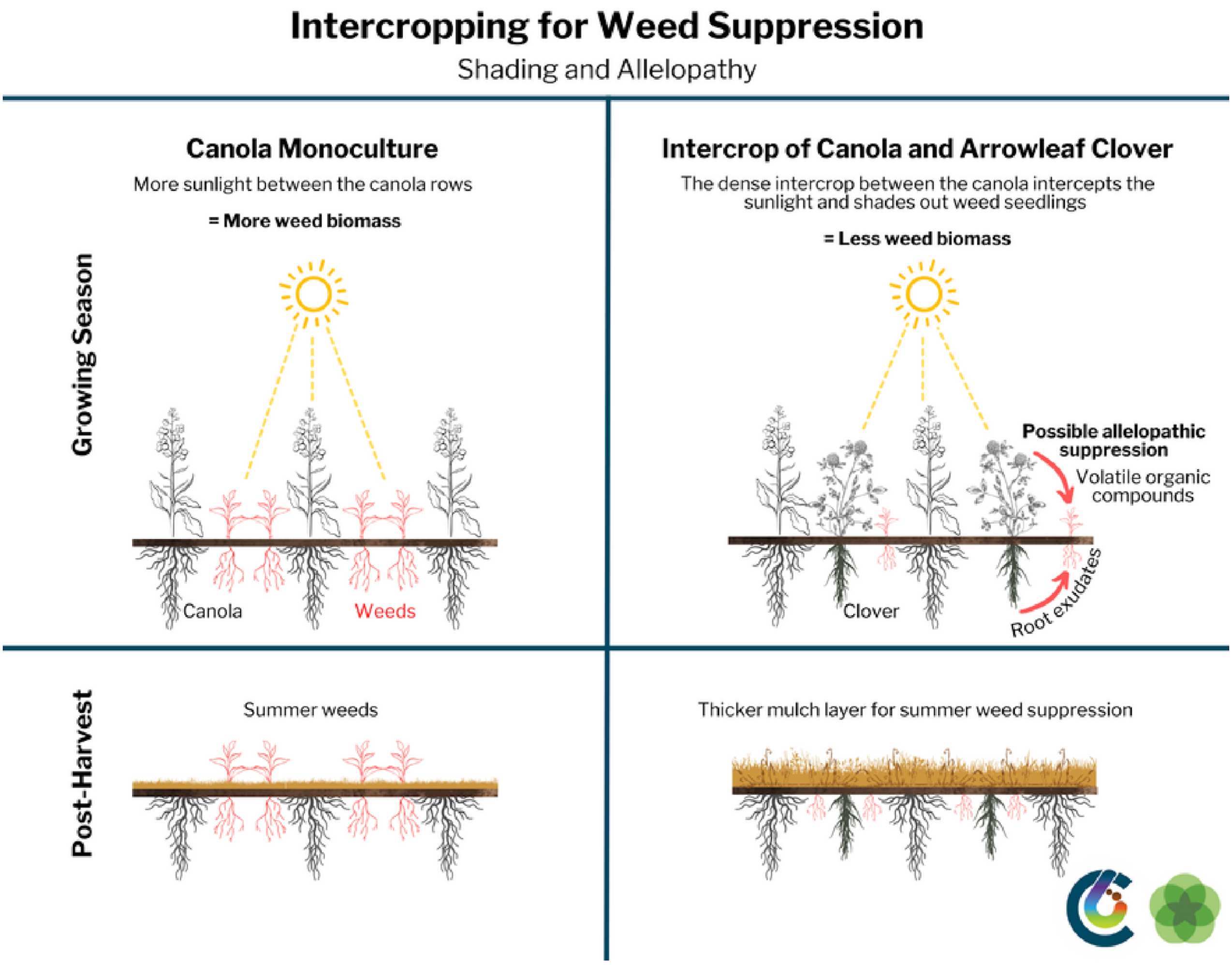
In Luke's opinion, he sees clear benefits to soil health from intercropping – with the intercropped paddocks having greater porosity and aggregation, leading to more friable soil.

He also observed more life and biological activity in the soil and a slightly darker soil colour compared to mono-canola crop paddocks.

NATURE'S FREE INPUTS

Weed Suppression

There is no doubt that herbicide management can often be more complex with intercropping. However, there are opportunities to exploit complementary interactions between the plant partners that lead to weed suppression. Intercrops can compete for resources, including sunlight and nutrients and release suppressive chemicals - allelopathy - which can reduce weed biomass.



Grower Insights

Reduced competition from weeds is also a clear benefit for Luke.

"I don't think we even saw a ryegrass plant in the paddock, whereas, in previous years, certain areas in that paddock had underperformed due to ryegrass numbers".

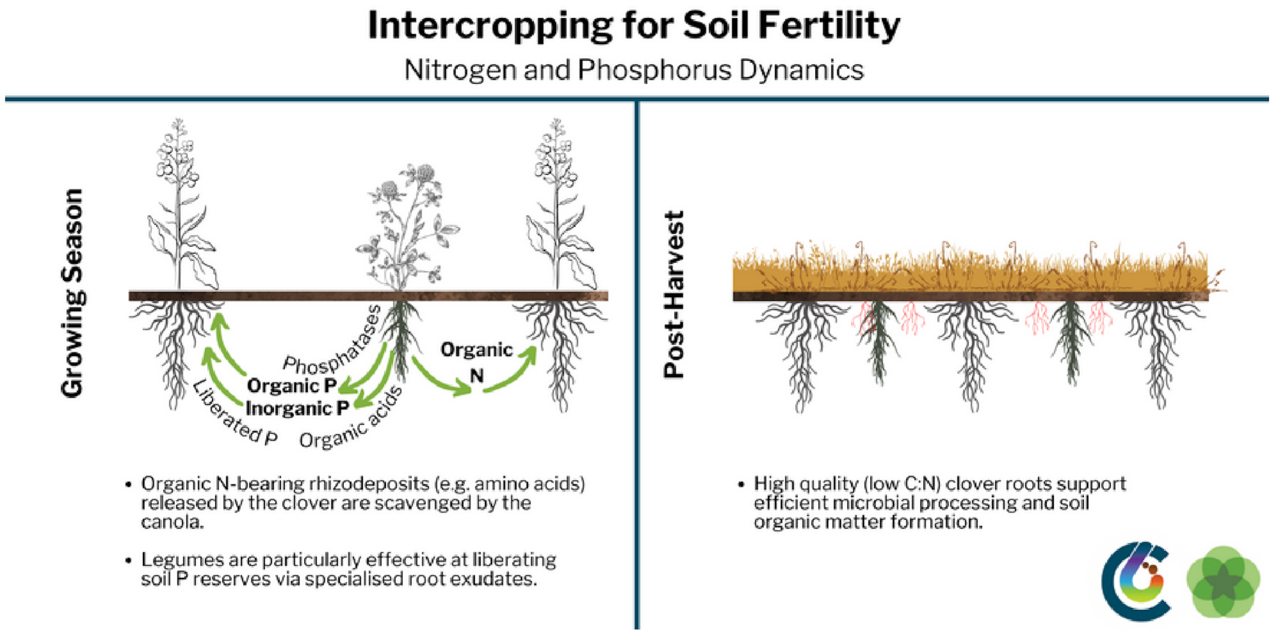
It's unknown whether this was due to shading or an allelopathic effect from the arrowleaf clover.

"I am convinced that the two years of arrowleaf (first year as a cover crop, second year in the intercrop) has changed the soil physiology so that it doesn't signal the ryegrass to germinate".

With ryegrass's ability to grow in compacted soils with poor structure, the improvements in soil porosity and aggregation observed by Luke could be one part of the answer. During this summer fallow, there was also less barnyard grass, blackgrass, hairy panic, sow thistle and prickly lettuce.

NATURE'S FREE INPUTS

More Nitrogen and Phosphorus



Sharing and Banking N

The ability of legumes to fix nitrogen and bank residual soil nitrogen for subsequent crops in the rotation is widely understood.

However, it has been demonstrated that legumes can share nitrogen with other plants in real time.

They do this by secreting nitrogenous compounds from their roots which are scavenged by plants growing near them, such as an intercrop.

In addition to the N-rich root exudates from legumes, organic nitrogen can be directly transferred between intercrops via mycorrhizal fungi growing symbiotically with intercrop roots.

Research has shown that root-root proximity is a key driver of these nitrogen-sharing processes, so it's important to plant the intercrop close enough to the main crop and/or choose an intercrop variety that has more lateral roots that reach out into the soil.

Unlocking Soil P for N fixation

Acquiring atmospheric N requires considerable amounts of phosphorus to support this energy-intensive process. This means legumes demand more P than most plant species and have adapted multiple strategies to scavenge soil reserves of this essential nutrient that is critical for N fixation.

A diverse array of highly specialised root exudates are able to unlock both inorganic and organic forms of soil P - which, upon being liberated - are taken up by both the legume and non-legume crops.

In the same way that N can be banked in crop residues for the next season, P and many other nutrients are also banked in crop residues, with legumes accumulating relatively high amounts of P. Importantly, this residue banked P is stored in an organic form which - as compared to inorganic P - is much less likely to fix onto soil mineral surfaces or lock up with other soil nutrients such as Al & Fe.

Due to being located below ground in the microbially active soil, the nutrients banked in root litter typically liberate faster than those in the shoot litter. Therefore plants with larger root systems have greater potential for nutrient release the following year, while shoot residues will typically release in subsequent years.

Things to Consider

Sowing

Choosing suitable varieties is as important as deciding which plant species to partner with, as varieties must have similar sowing and ripening dates.

Researchers internationally have observed the variability between varieties and acknowledged the need to breed varieties specifically for intercropping systems.

Should equipment allow, planting in alternate rows provides the opportunity to tailor the seeding depth for each plant species. However, many farmers have success planting all in one row with a 'middle ground' seed placement or sometimes even making two separate passes with the drill.

Harvesting and Grading

Once again, variety choice is key to ensure synchronised maturities and optimal harvestability with minimal losses. Anecdotally, many farmers have found that intercrops often align their ripening times, which may be due to ethylene gas released by the earlier species inducing ripening in the latter.

Intercropping can make harvesting easier with crops prone to lodging or fine-seeded species like flax or camelina.

Seed separating is a key barrier to adopting intercropping; however, the more comprehensive system benefits and economic gains from overyielding or input reduction savings can compensate for this additional expense. Typically, farmers start small by renting, borrowing or investing in simple gear such as sieves/screens, gravity tables or rotary drums.

Grower Insights

When sowing, Luke uses a disc seeder, and this limits the pre-emergents he can use, so he chose a pre-emergent that could be used for both canola and clover. With in-crop herbicides, Luke found that the two crop species limited him slightly. He could still use grass weed herbicides but was limited to broadleaf weed control.

Luke used a regular seed grader but would use a specialist grader if he wanted it to be immaculate. Luke decided to clean it enough to sell the canola and then use the arrowleaf clover on the farm.

Because Luke wanted to harvest both intercrops, he chose canola and clover because they have similar ripening times. However, the clover ripened slower than the canola, and this delay in harvest time led to some canola losses due to shelling, which was overcome somewhat by the additional clover yield.

Due to the very wet La Nina season in 2021, the arrowleaf clover was dominant and grew taller than the canola. This presented some challenges for harvest, with more lodging in the intercrop canola than in the mono canola.