INTERCROPPING

Increasing Crop Diversity

BRENDA FRICK AND JOANNA MACKENZIE | FEBRUARY 2016

Oat and pea intercrop at Paul Gaucher's farm, Coderre, SK, 2003
Photo credit: Brenda Frick

INTRODUCTION

Intercropping is growing two or more crops together, in the same place at the same time. The goal is to find synergies, or ways that the whole is greater than the sum of its parts, ways in which the plants together do better than they do alone, as single crops.

Natural systems are diverse, including a variety of plants, animals, microbes and fungi. This diversity is considered a key to their resilience and stability. Intercrops are one way to bring this diversity to the agroecosystem.

In traditional tropical systems, intercrops are commonly used to intensify production where land is limited, and to reduce the risk of failure. They are less common in extensive field crops, where single crops are considered easier to manage.

Intercrops can take many forms: annuals with annuals, annuals with perennials, perennial mixtures, mixtures of species, or mixtures of varieties. They can be used for forages, grain crops, cover crops, and green manures.

Intercrops are usually used for one of three reasons:

1. To grow two or more crops for the yield of both/all.
2. To grow one important crop, and protect it using other species/varieties
3. To grow a mixture as insurance that some crop(s) in the mixture will perform under varying or unpredictable conditions.

Although intercropping has interested people for generations, it has not been given a place of importance in field crop research. It is gaining interest among researchers interested in increasing system diversity in order to reduce dependence on synthetic fertilizers and pesticides

TYPES OF INTERCROP

There are many possible ways of classifying intercrops: by the perceived value of the different crops, by their intended use, by the degree to which the crops overlap. Perhaps one of the main distinctions is whether the crop is intended for seed, forage, or green manure/cover crop.

Intercrops harvested together for grain/seed

This type of intercrop is perhaps the most challenging, in that seeds need to ripen in the field at the same time, and in most cases the grains must be separable without excessive additional cost. Often ripening time can be 'adjusted' through careful variety selection, and by well-timed swathing. Seed separation by size can be easiest, for instance chickpea and flax, or field pea and mustard. However, separation can be more challenging than it first appears. For instance, peas and oats seem to be of different size, but some pea splits can end up in the oats, making the oats less marketable for milling.

Feed crops may have more flexible specifications, but buyers may still be unwilling to buy mixtures, even if they sell such mixtures. It is easier for them to make their blends from single crops than to adjust ratios according to intercrops.

Intercrops may also be mixtures of two or more cultivars of a single crop. These intercrops can provide yield stability if the different cultivars perform differently in response to disease, insects or moisture conditions.

"Diversifying the cropping system through strategies such as intercropping and cultivar mixtures may provide effective suppression of weeds and diseases and thereby improve grain yield and quality."

- Jacqueline Pridham, Department of Plant Science, University of Manitoba, 2006

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For every intercrop where seed is to be sold, be sure to check with buyers about their willingness to buy either the intercrop itself, or because seed cleaning may not be perfect, if they are willing to buy the separated crops if there are contaminants of the other crop in them.

Biomass crops

Sometimes intercrops are not grown for their seed, but for their biomass. This biomass can be used as livestock forage for grazing, green feed, silage or hay, and/or it may be used as a green manure or cover crop to boost soil fertility, increase soil organic matter, feed soil organisms, etc. Intercrops often include grasses, such as barley, oats, or sorghum, for instance and legumes, such as pea, lentil, clover or sweetclover. The right combinations can make excellent, high quality forages and green manures.

There is more flexibility in crop choice for biomass. If seed production is not a concern, even tropical legumes and grasses can play a role, especially if these are seeded in the mid-summer heat. Crop choice may be determined by forage value, for maximizing diversity, or with regard to seed availability.

Cover crop mixtures can include 12 or even more distinct species, and usually include cool season grasses (such as our cereal crops), warm season grasses (such as sorghum, corn, millet), as well as legumes, brassicas and sunflowers. These mixtures are intended to fill as many ecological niches as possible, maximizing resource use and providing good stands in a range of environmental conditions.

When using biomass crops that might go to seed (for instance if termination is delayed by untimely rain), it is best to consider their potential in following crops. For instance, it may not be a good idea to use a lentil variety in a cover crop that would be a problem in future lentil crops. As well, including species that act both as cover crop and cash crop lessens the interval between them, which may reduce the break from certain diseases.

Grain / biomass mixtures

Grain crops can be intercropped with forage/green manure crops. A common combination is for wheat to be underseeded with sweetclover. The wheat provides a cash crop while the sweetclover is establishing, and together the two crops provide excellent competition with weeds. The sweetclover might be broadcast into the wheat, perhaps followed by a post-emergence harrowing of the wheat to also incorporate the sweetclover. When the wheat is harvested, the sweetclover continues to grow, reaching its optimal green manure stage the next summer. This is sometimes referred to as a relay crop, as it is first wheat, then intercrop, then sweetclover.

Grains might also be grown with annual legumes, such as wheat and black medic. Here, the grain crop is harvested while the understory acts as a weed suppressing living mulch, which covers the ground and adds nitrogen.

Accidental

Intercrops can also occur by accident: when volunteers from a previous crop are abundant, or if crops are weedy. It makes sense to consider if these intercrop also have value.

Accidental intercrops due to volunteering are more common after some crops than others; flax, for instance, is a crop that volunteers quite readily. Knowing when volunteers are likely can allow you to make crop choices that benefit, or at least do not suffer from, these accidental intercrops.

While too many weeds in the crop can be detrimental, weeds can provide some of the same diversity boosting benefits as planned intercrops. For instance, wild mustard, stinkweed, and several other weeds are in the brassica or mustard family, and provide some potential benefit by making phosphorus more available; wild oats and wild mustard can provide structure and height that allows lentils and peas to climb, making the crop more upright, less disease prone, and easier to harvest.

Pasture seeding grain

Seeding grain into pasture is a form of intercropping that has been quite successful in Australia. They seed winter cereal crops directly into a stand of perennial grass pasture. Competition from the pasture is reduced by heavy grazing before seeding, and by seeding in the season when the pasture is beginning to go dormant. This system requires a fine balance between setting the pasture back while not causing permanent damage and establishing a strong cereal crop. Using small seeder openers, and wider row spacing minimizes the damage to the pasture.

BENEFITS OF INTERCROPPING

1. *Increasing diversity.*

Growing two crops at once provides more diversity both above and below ground. Diversity can have benefits to the entire agroecosystem. Soils benefit from crops with different rooting structures, accessing different portions of the soil volume. Root secretions and dead roots provide food for soil organisms. A varied diet allows different soil organisms to prosper. A variety of crops also increases habitat and resources for beneficial organisms above ground.

2. Overyielding.

Overyielding occurs when the intercrop yields better than the two crops would have if they were grown separately. Many studies report overyielding; most of these are warm-season intercrops. Crops that benefit each other, by providing physical supports or for climbing or that improve aeration, or that reduce disease transfer may increase the intercrop yield. If crops avoid competition by using resources differently, especially at different times, are likely to overyield.

When these synergies are not effective, intercrops generally perform better than the lower yielding crop, but not as well as the higher yielding crop in the mix.

3. Improved fertility and nutrient use.

Intercropping can improve nutrient use. Planting legumes such as peas, lentil, chickpea, sweetclover, alfalfa; with cereals such as wheat, barley or oats, can be effective. The cereal takes up most of the available soil nitrogen, which pushes the legume to form an association with Rhizobium bacteria to fix nitrogen. Nitrogen lost from the legume, for instance when plant parts die, can also be taken up by the cereal. When intercropped with legumes, wheat may produce more protein, and forage may be more nutritious.

4. Establishing a strong green manure.

Intercropping is an important method for establishing green manures. Sweetclovers, red clover and alfalfa are often established by underseeding them with cereal crops. This provides effective weed control in the young legumes, and some nutrient boost to the cereal.

Cereals and legumes may be intercropped as a green manure, with both the cereal and legume turned under for soil building. The legume provides nitrogen, but decomposes rapidly. The cereal decomposes more slowly, providing organic matter to the soil for longer.

5. Weed control.

Intercrops are often less weedy than sole crops. Planting a mixture of crops can fill more ecological niches, providing fewer opportunities and resources for weeds. Flax, field peas and lentils often compete poorly against weeds, especially early in the season when their growth may be slow. Planting cereals with early vigour among the weaker crops can reduce weed pressures.

Balancing competitive ability of crops can be challenging. Competing with weeds is desirable, but competing with a higher value crop is not. Often the more competitive crop is seeded at a lower seeding rate than the less competitive, and often higher value crop. For instance, wheat might be seeded with flax, or oats with lentils. Intercrops of spring seeded fall rye with flax provide good weed suppression. However, it is easy to overwhelm the flax in this mixture. Intercrops of lentils with flax show promise for weed suppression; however, caution should be taken, as lentil chips can be difficult to clean from flax.

6. Improved harvest.

Intercrops of plants of varying form can reduce the occurrence of lodging. For instance, leafy peas have a tendency to lodge. Adding semi-leafless pea cultivars to the mix reduces lodging. The leafy peas offer more weed competition; the semi-leafless peas are less likely to fall over.

Planting cereals, such as wheat, barley or oats with lentils can allow the lentil to climb the cereal, and keep lower pods out of the soil. This makes them easier to harvest, and reduces earth tag (soil sticking to lentil seeds). A flax and chickpea intercrop similarly opens up the canopy of the chickpea, and reduces loss of bottom pods.

7. Insect control.

Intercropping can make it more difficult for pests to find their host plant. Many insects find their target by smell. The addition of a second crop in the field can disguise the scent for searching insects.

Intercropping canola with barley reduces flea beetle and diamondback moth damage to the canola. Similarly, intercropping mustard, with barley or wheat reduces problems with these insects..

Another interesting example is midge resistant wheat. Midge resistant wheat is sold as a mixture with non-resistant wheat, in hopes of providing a refuge for the wheat midge and slowing the adaptation of the midge to the resistant wheat.

8. Disease reduction.

As mentioned earlier, intercrops can change the environment within the stand. For instance, chickpea is vulnerable to Ascochyta blight. Intercropping chickpea with flax alters the crop canopy, and improves airflow. This reduces the spread of disease in the chickpea.
Similarly, improved air movement in intercrops of pea and oats can reduce pea disease and an intercrop of heritage and modern wheat cultivars reduces the overall disease pressure in the stand and stabilize yields.

9. Reduce weather risk.

Intercrops can be used to help compensate for variable weather conditions. For instance, with a mixture of sweetclover and red clover, the sweetclover performs better under dry conditions, or on the knolls, whereas the red clover does better in wetter conditions, and in in the valleys. Seeding them together is a form of weather insurance. This can be an important tool in an uncertain climate.

10. Ease of harvest.

Flax, with its fibrous stems, can be a difficult crop to harvest. Intercropping wheat with flax can ease cutting. Wheat can also hold the flax in the swath. Intercropping peas and lentils, with upright cereals, increases the height of the pods, making cutting or combining easier. For delicate seeds, like peas, having additional material from an intercrop that can buffer them as they pass through the combine, augers and other gear, and may reduce damage and improve quality.

11. Economics.

Intercrops can provide economic benefits in a number of ways. Overyielding and improving yields of high value yet poorly competitive crops comes with economic gains. Intercropping can improve crop quality by reducing insect and disease damage, and helping to provide proper fertility to support a healthy crop. Intercrops can provide income stability as well, by mixing crops that perform well in a variety of conditions. Intercropping increases the crops per acre, which again increases income stability.

Intercrops can also provide income in years that might otherwise not produce a cash crop. Establishing forages or green manures with a nurse crop not only aids in the establishment of the legume, but provides an opportunity for a cereal harvest as well.

PRACTICAL CONSIDERATIONS

Intercropping is not a well-established concept in industrial agriculture. A sound understanding of crop production may not be enough to answer the questions that arise when growing two or more crops together.

Picking appropriate mixtures: agronomy vs economy
Some mixtures just make sense, agronomically. For instance, oat and pea offer excellent synergies, with the oat providing support for the pea, and the pea providing its own nitrogen, and thus not competing with the oat for it. However, pea and oat may be a challenge to separate, and therefore to sell. It is an agronomic success, but it may not be an economic success. It is important to check with buyers before planting intercrops, to assure that they will buy them once they are harvested.

Timing

If intercrops are to be harvested for grain, it is important that they ripen together. Usually this can be managed by selecting cultivars with similar maturity dates. If this is not possible, the longer season crop may be seeded earlier. There will likely be some crop loss upon seeding of the second crop. This may be reduced if the two crops are cross-seeded. A second option is to swath the intercrop before the earlier crop shells out, and hope that the later crop will ripen in the swath. In this case, a less shattering cultivar would be preferable.

Seed separation

Most buyers will not accept mixed crops. Almost any mixture can be separated, at least into three fractions (seed A, seed B and the mixture of A and B), but this can be costly. Seeds of different sizes, shapes and density are most easily separated. However, if seeds are damaged, their parts can be difficult to remove, for instance, pea splits in oats, or oat thins in black lentil. Mixtures of cultivars, such as black and green lentils, or yellow and green peas are very costly to separate, and may not be marketable.

Check with seed cleaners, and buyers before sowing intercrops intended for grain harvest. Harvest and clean carefully to avoid problems with damaged grain.

Seasonality

Intercropping offers the potential to cover more of the season.

Spring seeded fall rye can be an excellent weed suppressing living mulch that won't grow overly tall when planted with flax. The rye also offers ground cover in the fall, and following spring. Intercropping sweetclover with wheat allows a profitable grain harvest while providing fall and spring ground cover, substantial nitrogen benefits and no need to seed in the second year. The new concept of pasture seeding grains makes use of a waning pasture to gain a marketable grain crop.

The range of seasonally adapted plants can be increased when using forage or green manure intercrops. Long-season crops that would not ripen in our growing season can be used for biomass rather than seed.

Cocktail mixes

Cocktail mixes are cover crop mixes that aim to maximize diversity, including as many plant types as possible to make use of all ecological niches and all available resources. These mixes contain cool season grasses that perform well in the spring and fall, warm season grasses that thrive in the summer heat but likely won't survive to set seed, as well as quick growing and nutrient mining brassicas, legumes that can associate with Rhizobia to fix nitrogen, and other broadleaved crops that can produce a lot of biomass. In combination, these cocktail mixes can produce cover crops that thrive in a number of climate conditions, outcompete weeds, improve nutrient availability and soil health, and provide lots of soil organic matter.

Seeding rates

There are few recommendations for seeding rates for intercrops. Equal intercrops can be planted at full rate, two-thirds or three-quarters of the recommended seeding rate.

In some instances, seeding rates can be adjusted to favour one crop in the mix over another. For instance, if flax is the main crop, and wheat is added to improve weed control, flax might be seeded at the normal rate, while wheat might be seeded at half rate. In the case of fall rye, which is highly competitive, the seeding rate might be less than half.

Seeding methods

Intercrops may be seeded together, or in separate operations. To establish intercrops in a single seeding operation, seeds may be mixed in the seed box. This works best for seeds with similar density, so that gravity does not sort them during transport resulting in uneven mixes. For seeds with different densities, using separated seed boxes may result in the most even stands, and can allow better and finer adjustments of seeding rates for each crop. When large and small seeded crops are planted together, the small seeded crop may even be placed in the fertilizer box, while the larger seed is placed in the seed box.

Intercrops can also be planted in multiple operations. Crops can be cross-seeded at 45 or 90 degree angles, providing even ground cover. If seeders use wide spacing, and have sufficient precision, once crop might be seeded between the rows of the other. Another option is to use alternating strips, usually each a seeder width. Strip planting may alleviate some harvest concerns, but may not always result in as great a synergy as other planting patterns, as the different plants are not in as close contact.

Broadcast seeding followed by harrowing can allow the establishment of a relay or underseeded crop into an emerged crop. For example, sweetclover may be broadcast seeded into standing wheat.

Harvest

There are also a number of ways that intercrops may be harvested. The mixed crops may be harvested together, with seed separation after harvest. When harvesting mixed crops together, swath and combine slowly and gently, to avoid damage to either crop. Splits are often difficult to clean from mixed crops. For some more delicate crops, having other material in the air stream may actually gentle it, protecting the grain from damage.

If the crops differ enough in height at harvest, it may be possible to harvest the higher crop, then the lower. This has been done successfully with wheat and soybean.

Crops may differ enough in maturity that they can be harvested separately; for instance, flax and fall rye, or wheat and sweetclover.

Most mixtures should be separated before storage. Storing a crop mixture is difficult if the two crops have different optimal moisture content for storage. Storage of seeds of different sizes can also lead to compaction and can reduce airflow. For more information on seed cleaning and storage, see the Maintaining Crop Quality factsheet.

RECOMMENDATIONS FOR HOW TO PROCEED WITHOUT RECOMMENDATIONS

Intercropping is poorly understood in industrial agriculture. There are few recommendations developed for intercropping in our region. To determine the best procedures, it is useful to experiment, on an acreage that is small enough to not have a major impact on your income, but large enough to test equipment suitability. It may be useful to try several seeding rates for your intercrop experiment.

Seeding rates for intercrops are usually based on the seeding rate recommendations for the crop on its own. These are then scaled up or down depending on the goals of the intercrop and value and competitive ability of the crops. For instance, a pea-oat test might include seeding rates of 1 pea: ½ oat; ¾ pea: ¾ oat; ⅔ pea: ⅔ oat; ½ pea:1 oat. For each of these, 1 would be the normal recommended rate for the crop on its own. For an intercrop with a differing competitive abilities and values, such as flax and rye, seeding rate tests might include 1 flax: 5% fall rye; 1 flax: 10% fall rye; 1 flax: 25% fall rye. As a comparison, you may also want to plant non-intercropped stands of each crop in the mix.

SUMMARY

Intercrops have the potential to increase cropping diversity, reduce weeds, insect pests and diseases, and improve yields. They offer potential agro-ecosystem advantages associated with increased diversity. Because they are more complex, they require more management and more decisions. Although interest is growing in intercrops, there are few specific guidelines. Test plots may help producers determine the procedures they need for large-scale intercropping.

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Questions? Call 1-800-245-8341
Email info@pivotandgrow.com
www.pivotandgrow.com