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(J. Jacobs, NDSU)

Intercropping for Grain Production in the Northern Great Plains

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What is intercropping?

Intercropping is a term used to describe growing multiple crops together in the same field at the same time. The crops may be seeded together as a mixture in the same or alternating rows. There are multiple approaches to intercropping, but in this publication, we are specifically discussing planting and harvesting two or more grain crops simultaneously.

Intercropping is not new in agriculture and has been practiced for thousands of years. Growers may be familiar with intercropping forages, for example, growing field pea and oat together or an alfalfa-grass mixture that are harvested for hay. However, adoption of intercropping for grain production is a recent development in the Northern Great Plains.

Intercropping allows the grower to take advantage of synergies that may occur between crop species. For example, field pea can climb up canola stems, resulting in reduced lodging and enhanced pea harvestability. Reasons for adopting intercropping include an interest in soil health, reduced production risk, decreased input costs and increased land use efficiency. Intercropping can potentially manage production risk in one or more of the following ways: reducing disease incidence or severity, spreading weather risk among multiple crops, increasing crop competitiveness (biological weed control), reducing fertilizer needs, and increasing harvestability. In some cases, intercropping can increase land use efficiency by overyielding compared to a monocrop. Overyielding is when the combined yield of both crops is greater than the yield of either crop grown alone using best management practices.

While there are potential benefits to intercropping, thorough planning is needed. In this publication, we present factors that need consideration and discuss in detail how to approach two of the most-commonly practiced intercropping mixes in the Northern Great Plains: chickpea-flax and field pea-canola.

Planning ahead: considerations for intercropping

Crop Selection

Carefully select the crops you will grow together when intercropping. Pairing cool-season with cool-season crops or warm-season with warm-season crops is recommended. Consider if the intercrop partners differ substantially in maturity or the timing of their peak water demands and how this could be helpful or pose a challenge in your region. For example, if you are in a region where moisture is most abundant early-season but then tends to be short in late summer, intercropping a species that needs water early in the growing season with another species that needs water late will likely compromise yield of the later crop.

Seed size is another important factor when choosing which crops to grow together. A substantial difference in seed size between intercrop partners facilitates post-harvest separation but can pose a challenge for optimal seeding depth. Regarding marketing of intercropped grain, keep in mind that some crops are considered allergens (e.g., wheat or soybean) and are not tolerated as contaminates in certain crops if grown for the food-grade market.

Planting

Planting logistics are an important aspect of intercropping. Combinations with very different seed sizes can be planted in separate passes in a crossed pattern to allow for optimal seeding depth for both crops. However, seeding in two passes may not be practical on all farms. If the crops are planted in a single pass, determine if you are able to plant each crop at its recommended seeding depth. Planting one crop using the seed tubes and the other using fertilizer banding units may be an option, but be aware that seed planted through the fertilizer tubes may not get optimal seed-to-soil contact. If this is not possible, planting both crops at the same depth can be done but may not maximize emergence of one or both crops. For combinations with similar seed size, for example oat and field pea, planting the two crops at the same depth is not a problem.

Intercrops can be planted in the same row or in alternating rows depending on your equipment design (Figures 1 and 2). Planting the crops in alternating rows may be beneficial for optimal seed emergence if different seeding depths are required. Seeding rates will depend on which crop you consider to be your primary crop and your goals. **Identify the primary crop in your mix and tailor your practices toward maximizing the primary crop yield and the principle benefits you want to achieve.** Select a planting date that is suitable for both crops based on frost tolerances and adjust variety maturity as needed.

Figure 1. Chickpea-flax intercrop planted in alternating 10" rows. (C. Keene, NDSU)

Figure 2. Lentil-flax intercrop planted in the same row. (T. Binde, NDSU)

Fertility

Many intercrop mixes incorporate legumes which fix nitrogen through microbial symbiosis when the appropriate bacteria are present. Excess nitrogen can inhibit the formation of nodules and establishment of these nitrogen fixing symbioses. Therefore, it is important not to over-fertilize legume partners such as chickpea or field pea, or plant a legume-containing intercrop in a field with high residual nitrogen if the goal is to maximize nitrogen fixation.

Just as when growing monocrop legumes, inoculation with the proper bacteria is needed to ensure nodulation. If the primary crop is a legume, one may reduce or eliminate the application of nitrogen fertilizer so that the intercrop partner does not out-compete the legume.

Supplemental phosphorous or potassium may be needed as a starter fertilizer which can be determined from a soil test. More detailed information on pulse crop fertility can be found in the Pulse Crop Production Field Guide (NDSU A1922).

If the primary crop is a non-legume, then fertility needs should be determined based on a soil test and the recommended fertilizer rate adjusted to the seeding rate of the non-legume.

Pest Management

A preventative weed management plan is critical to ensure success with intercropping as in-crop herbicide options are typically limited. For many intercrop partners, there may be two to four pre-plant herbicides available (in addition to previous fall-applied herbicides) but only one or two in-crop options, if any. Several intercrop combinations reduce weed pressure later in the growing season but still require a clean field during stand establishment and early growth stages for maximizing yield. A fall application of a product with good residual activity such as Valor® (flumioxazin) can help manage challenging winter annual species such as horseweed (also called marestail) and narrowleaf hawksbeard and provide some control of early spring-emerging weeds such as kochia. The North Dakota Weed Control Guide (NDSU W253) provides information on plant-back intervals after fall or spring herbicide application and is a useful resource for planning intercrop partners.

Growers have reported reduced disease pressure in certain intercrop mixes. For example, in a pea-canola mix a fungicide is omitted where it is typically used in monocropped peas for Ascochyta blight control. Similarly, Ascochyta blight severity may be reduced in a chickpea-flax intercrop compared to a chickpea monocrop and fungicide applications reduced.

Harvest

The goal is to harvest the intercropped species at the same time, so it is important that the crops mature on a similar date. Alternatively, crops may be left in the field while the intercrop partner matures. However, there may be risk associated with yield or quality loss in this situation. Carefully review the maturity of the varieties you select as intercrop partners and choose those which are the most compatible. The need for desiccation or swathing may be increased for some intercrop combinations to foster more uniform dry-down.

As a result of having two or more different crops, setting the combine for an intercrop mix may be more challenging than when harvesting a monocrop. The combine settings should be adjusted to avoid cracking the larger seed and blowing the smaller or lighter seed out with the chaff. Because of this, foreign material may be noticeably higher in the harvested grain. Although purchasing new equipment is not recommended when initially adopting intercropping, a draper header may facilitate harvest.

Seed Separation

Intercrop mixes may be stored post-harvest together or separately but in both cases should be cleaned to be free of plant material and crop residues that promote spoilage. When storing together, make sure each crop is at its respective safe storage moisture content. The cost and plans for separating seed should be determined before proceeding with intercropping. Many growers who practice intercropping own seed cleaning equipment such as a Kwik Kleen™ or air sieve mill to reduce the cost of separating the crops post-harvest (Figure 3). When choosing an intercrop mix, consider seed size and the ease of separation. Chickpea-flax and

Figure 3. Separating and cleaning pea-canola intercrop using a portable seed cleaning unit. Mixed grain enters the cleaner via the auger in the middle, clean canola exits via the blue auger on the right, clean pea exits via the brown auger on the left, and screenings are collected in the round blue tub behind the cleaning unit. (M. Jacobs)

pea-canola are good intercrop partners because their vastly different seed sizes facilitate separation (Figure 4).

Weed seeds can make harvested intercropped grain separation difficult, so selecting a field with low weed pressure will facilitate separation and cleaning. Having some form of air control during the cleaning/separating process further facilitates separation. Air (or wind) helps remove lighter weed seed or foreign material from the grain.

Crop Insurance

Crop insurance regulations may change so be sure to contact your Farm Service Agency (FSA) office and crop insurance agent to determine the most up-to-date regulations regarding intercropping. At the time of publication, North Dakota growers who can demonstrate a successful history of intercropping and associated records (two or more years) are eligible to insure one of the intercrop partners (the primary crop) with a letter of recommendation from their county agent. The two year history must be of the same intercrop mix (ex. pea-canola) and the associated insurance will be only for that mix. If you want to try other combinations, the two year production history must be established for each unique combination. Before proceeding with intercropping, discuss your plans with your crop insurance and county Extension agents.

Crop Rotation

Intercropping can make planning crop rotations more challenging. Ideally, one of the intercrop partners is new to your operation and fits into your current crop rotation. However, pulse crops require long crop rotations to manage root rots and foliar diseases. Intercropping does not negate the need for breaks between susceptible crops. It is important to maintain proper rotation intervals and not shorten the rotation based on the presence of two crops instead of one.

Figure 4. Chickpea-flax intercrop sample prior to separation. (C. Keene, NDSU)

Chickpea-Flax

The chickpea-flax intercrop has been adopted on several thousand acres in Canada and on hundreds of acres in North Dakota and Montana, with the primary goal of managing Ascochyta blight, a potentially devastating foliar disease of chickpea. Typically, chickpea is the primary cash crop in this mix with the flax being grown for chickpea disease management benefits. Farmers who have adopted this mixture have reported reduced fungicide applications for Ascochyta blight, reducing applications from two to five per year to one to three. Research results are starting to support this claim. A secondary benefit some growers report with chickpea-flax intercropping is more rapid chickpea dry down and an increase in chickpea harvestability.

Planting

When intercropping chickpea-flax, the seeding rate of chickpea will be similar to the rates used in a monocrop with a light rate of flax (5-15 lbs per acre) added as a companion. Recommended planting depths are 0.75 to 1.5 inches for flax and 1 to 4 inches for chickpea depending on soil moisture and seed size. Small-seeded desi type chickpeas should be planted 1 inch below moist soil while large-seeded kabuli types should be planted 2 inches below moist soil. Planting deeper to favor chickpea establishment is recommended but may reduce flax stand; a slightly higher flax seeding rate could be used to compensate in this situation.

Planting chickpea and flax in alternating rows, due to chickpea's deeper planting depth, may result in a more uniform stand and improve harvestability compared to planting the crops together in the same row.

Fertility

The primary crop in this mixture is typically chickpea. Therefore, some growers have opted not to fertilize this mixture to maximize biological nitrogen fixation. In this scenario, establishment of the nitrogen fixing symbiosis is critical and chickpea seed inoculation is highly recommended. Chickpea needs to be inoculated with *Mesorhizobium ciceri* or *M. mediterraneum*, rhizobium species which are specific to chickpea. Starter fertilizer to supply phosphorous or potassium may be needed depending on the results of a soil test.

Pest Management

Ascochyta blight of chickpea caused by the fungal pathogen *Ascochyta rabiei* is an extremely aggressive disease and can cause complete yield loss if not managed (Figure 5). In monocropped chickpea, one to five fungicide applications are required depending on how conducive environmental conditions are to disease development. Growers have reported reduced Ascochyta blight in chickpea intercropped with flax and on-going research supports this observation (Figure 6). The mechanism of improved disease management through

Figure 5. Ascochyta blight of chickpea. (A. Kalil, NDSU)

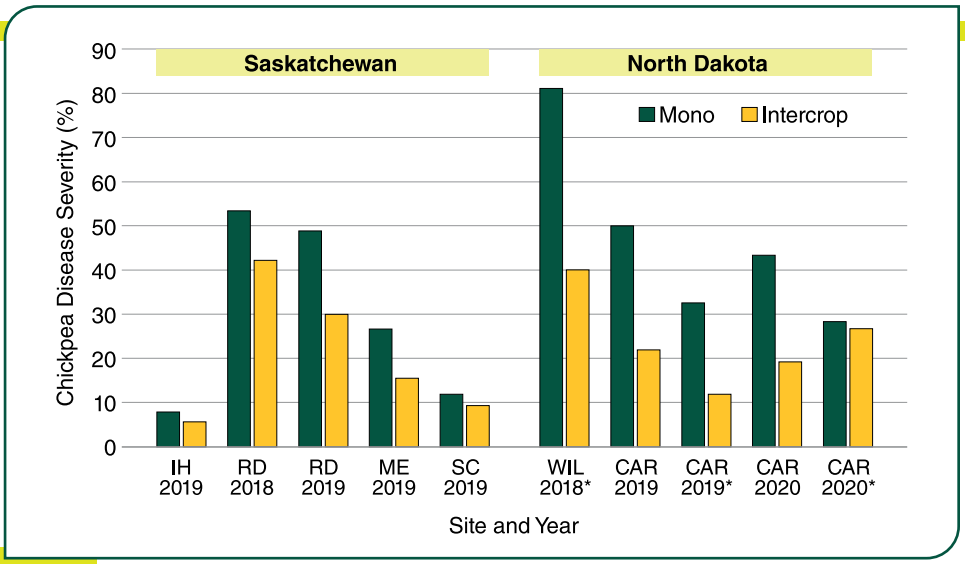

Figure 6. Ascochyta blight severity in monocrop or chickpea-flax intercrop in research studies conducted from 2018-2020. Data comes from multiple sites in Saskatchewan, Canada and North Dakota. IH = Indian Head, SK; RD = Redvers, SK (L. Shaw); ME = Melfort, SK (D. Leach); SC = Swift Current (M. Hubbard), SK; WIL = Williston, ND (C. Keene); and CAR = Carrington, ND (M. Ostlie). * = study treated with fungicides for management of Ascochyta blight.

intercropping has not yet been definitively identified, but it is often associated with modification of the microclimate within the intercrop leaf canopy that alters temperature and moisture (humidity) conditions in a way that are not favorable for disease progression.

Severity of Ascochyta blight is determined both by moisture (humidity and rainfall) and the presence of nearby infested crop residue which is the main source of the pathogen. Thus, management of Ascochyta blight in an intercrop will still require careful monitoring of these factors. To minimize Ascochyta blight, a three-year break between chickpea crops is recommended and growers should not plant chickpea next to fields that were planted to chickpea the previous growing season. Selection of a variety with a high level of genetic resistance to Ascochyta blight and seed testing for the pathogen is also important. By following these recommendations and combining them with intercropping, a grower may be able to reduce the number of fungicide applications for Ascochyta blight.

Weed management in the fall and spring prior to planting the intercrop, particularly for broadleaf weeds, is highly recommended, as there are no broadleaf in-crop options available for this mix. Group 1 grass herbicides such as Select® (clethodim) may be used.

Harvest

Chickpea is highly indeterminate and when rainfall occurs in late summer, harvest can be delayed. Chickpea will continue to flower and set seed as long as moisture is available, so in some years, there may be ripe pods on the bottom of the plant and green pods on the top. Green chickpea seed present in harvested grain is problematic and is likely to incur a discount.

Another benefit of intercropping chickpea with flax is that it can improve dry down and speed harvest (Figure 7). In some years, chickpea can be straight cut without the use of a desiccant when intercropped with flax; however, desiccation may still be needed in a wet year to ensure a timely harvest.

The combine should be set to accommodate the larger chickpea seed to avoid cracking and quality discounts. Growers who intercrop chickpea and flax have reported that the chickpea seeds help thresh the flax bolls. The fan should be turned down to avoid loss of the flax.

Recommended storage moisture for flax is 9% and for chickpea, 15%. This mix can be stored together prior to separation; however, it is critical to ensure both crops are dry enough for safe storage to prevent spoilage.

Figure 7. Chickpea-flax intercrop nearing maturity. (C. Keene, NDSU)

Field Pea-Canola

Field pea-canola is the most widely adopted intercrop in Saskatchewan and is a common first choice for farmers trying intercropping. Intercropping field pea and canola has been adopted as a way to address lodging problems in pea. The canola holds the pea plants up, increasing the height of the bottom pod from the ground and thus increasing pea harvestability and crop quality (Figure 8). Pea-canola, sometimes called "peaola," can also reduce marketing risk, as price fluctuations for pea can be offset by canola prices and vice versa. North Dakota growers have reported an economic advantage to intercropping pea with canola compared to monocropped pea due to the additional value of the canola crop grown on those acres and, in one case, increased pea yield.

Planting

For pea, a planting depth of 2 inches is recommended with a minimum depth of 0.5 inch. Exact seeding depth for pea depends on soil moisture as pea should be seeded into moist soil whenever possible. Canola is typically planted 0.5 to 1 inch deep, with the shallower depth necessary for smaller seeded hybrids. Planting at 1.5 inches may be possible with larger seeded hybrids. Seeding deeper than 1.5 inches may reduce canola stand. Depending on soil moisture, canola and pea may be planted simultaneously at the same depth (Figure 9). If the topsoil is dry and pea needs to be planted deeper than 1.5 inches, it may be necessary to use equipment capable of seeding the crops at different depths or planting in two passes. Growers will need to experiment with relative seeding rates of each crop to achieve their goals. For example, a high rate of pea may smother the canola and fail to achieve the goal of increased harvestability for the pea; conversely, a high rate of canola can out-compete field pea later in the season.

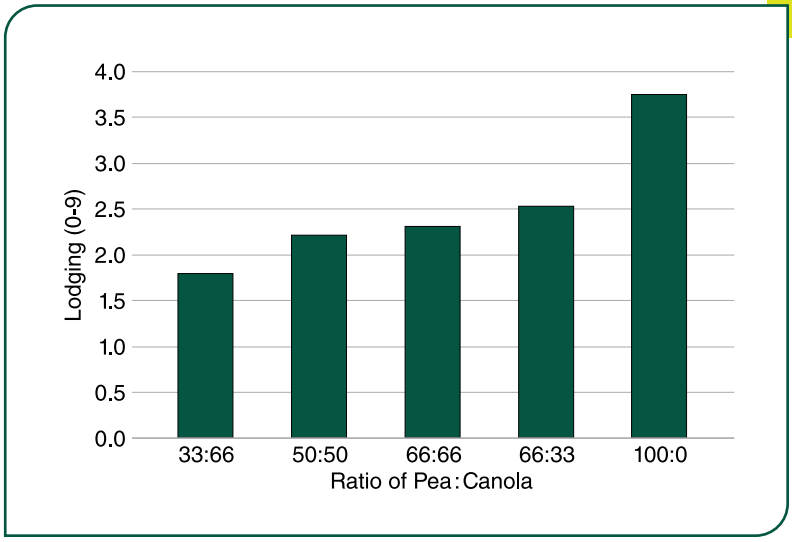

Figure 8. Comparing monocrop to intercrop for lodging response in pea across three environments over two years (2019 and 2020). Lodging was evaluated using a 0-9 rating system where 0 = standing straight and 9 = lying flat. Pea and canola were intercropped at ratios relative to their monocrop seeding rates (pea:canola): 33:66 = 60 lb/ac and 2.6 lb/ac; 50:50 = 90 lb/ac and 2 lb/ac; 66:66 = 119 lb/ac and 2.6 lb/ac; 66:33 119 lbs/ac and 1.3 lb/ac; 100:0 180 lb/ac and 0 lb/ac.

Figure 9. Pea-canola emerging in the same row. (M. Ostlie, NDSU)

Pea-canola intercrop. (M. Ostlie)

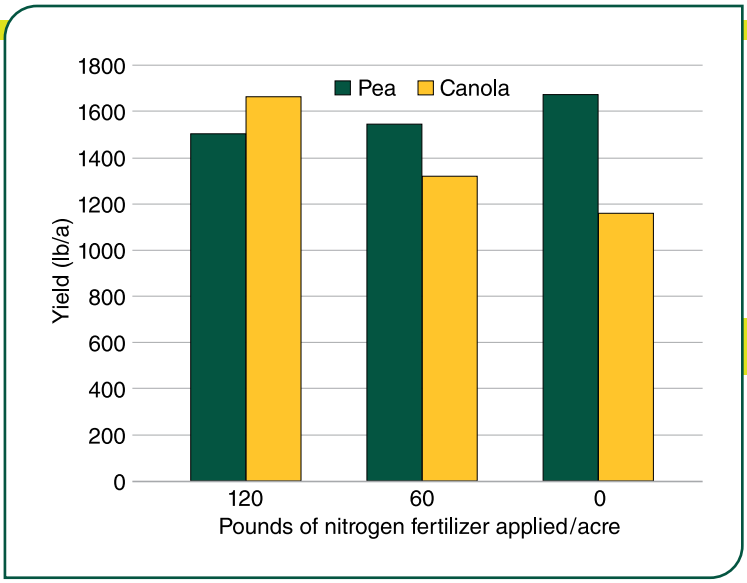

Figure 10. Pea-canola intercrop yield response to nitrogen fertilizer across three environments over two years (2019 and 2020). Yields presented are averaged over four different seeding rates as increasing nitrogen fertilizer decreased pea yield regardless of pea-canola seeding rate.

Fertility

Fertilization of pea-canola depends on the primary crop of interest. If the primary crop is canola, research has shown that canola yield will suffer if no nitrogen or sulfur fertilizer is applied (Figure 10). Soil test to determine residual N levels and adjust the nitrogen rate based on the canola seeding rate. Increased N availability will favor canola, and pea yield may be reduced with increasing rates of N fertilizer (Figure 10). N fertilization may also reduce N fixation. At the very minimum, a sulfur-containing fertilizer such as ammonium sulfate should be applied to support the canola. Detailed information on canola fertility can be found in the publication, Fertilizing Canola and Mustard (NDSU SF1122).

Pest Management

Some North Dakota growers who have intercropped pea and canola reported omitting a fungicide for control of foliar disease such as Ascochyta blight in pea where they would have sprayed a monocrop pea field. In theory, reduced crop density may impair the spread of fungal pathogens in the crop canopy. However, this has not been well-studied or reported in the scientific literature. Selecting a pea variety with powdery mildew resistance will also help reduce disease risk.

Flea beetle populations were monitored in both monocropped and intercropped canola over three years in research studies conducted in southeast North Dakota. In one out of three study years, the flea beetle population was lower in the intercropped compared to the monocropped canola, but in the other years there was no difference. Thus, intercropping canola with pea may or may not affect flea beetle management.

A pre-emergent herbicide is important for weed control in a pea-canola intercrop. Sonalan® (ethalfluralin) is registered for use in both pea and canola and can reduce the weed pressure later in the growing season. Group 1 herbicides labeled for use in both crops may be used for grass weed control.

Harvest

Both canola and field pea are susceptible to shattering once the crop is ripe. It is best to pair a late-maturing field pea variety with an early-maturing canola variety so that the field ripens uniformly. Set the combine to accommodate the larger pea seed to avoid cracked peas. It is important to remember that when harvesting the two crops together, more of the canola stem is taken through the combine compared to harvesting monocrop canola. A pre-harvest desiccant may be useful to facilitate dry down of the canola.

Pea-canola seed. (M. Jacobs)

Intercrop Combinations Summary

Table 1. Benefits and risks of common intercrop combinations. Growers should consider which benefits and risks are acceptable for their own operation. For some combinations, little research-based information is available.

	Benefits						Risks		
Crop combinations	Reduced fertilizer needs	Reduced insect pressure	Reduced disease pressure	Enhanced residue persistence	Enhanced dry down	Improved crop architecture/harvestability	Uneven maturity	Weed control difficult	Difficult post-harvest separation
Chickpea + Flax	◑	○	●	●	●	○	○	○	○
Pea + Canola	●	●	◑	●	○	●	●	◑	○
Mustard + Lentil	●	◑	◑	●	○	●	○	●	○
Flax + Lentil	◑	○	○	●	○	●	◑	●	○
Oat + Pea	●	○	○	●	○	◑	●	○	●
Pea + Canola + Oat	◑	◑	○	◑	○	○	●	◑	●

Legend

- ○ No evidence of benefit
- ◑ Possible benefit
- ● Likely benefit
- ○ No evidence of risk
- ◑ Possible risk
- ● Likely risk

Conclusions

Intercropping can be a valuable production risk management tool, and North Dakota growers are finding success using this strategy to reduce reliance on costly inputs and increase profitability. Intercropping may also increase the ease of crop production and facilitate the adoption of new crops in an operation. Intercropping practices will look different from farm to farm, and it is recommended to start with small areas to test the best methods for intercropping with the land and equipment available. Identifying and taking advantage of crop synergies and careful planning are keys to successful intercropping.

Resources

Pulse Crop Production Field Guide for North Dakota (A1922)
Flax Production in North Dakota (A1038)
Canola Production Field Guide (A1280)
Fertilizing Canola and Mustard (SF1122)
North Dakota Weed Control Guide (W253)
Growing Pulse Crops Podcast. www.growingpulsecrops.com

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