Organic Agronomy Training

Dr. Martin Entz – University of Manitoba

Lesson 2 | Part 1

Crop Establishment and Seeding Systems

Organic Agronomy Training

This training was developed and delivered by Martin Entz, PhD, Department of Plant Science, University of Manitoba. It is intended for private and public sector agronomists who want to respond to the growing demand from producers for more information about organic grain production. Grain farmers considering a transition to organic or current organic practitioners who want to learn the theory and latest science will also find the course valuable. The course was designed with the Prairies in mind, however agronomists in other ecoregions will learn universal principles of organic production.

The training consisted of five 75 minute live online sessions over two weeks in January 2023:

- January 5: Designing Cropping Systems with a Focus on Nutrient Management
- January 6: Crop Establishment and Seeding Systems, Tillage and Weed Control
- January 10: Pest Management with a Focus on Disease, Insects (and Weeds)
- January 12: Soil Management for Organic Production: Putting Theory into Practice
- January 13: Question & Answers

All course content (lesson recordings, presentations and notes) can be accessed on pivotandgrow.com.

The Organic Agronomy Training was developed as part of the Prairie Organic Development Fund's Canadian Organic Ingredient Strategy.

The Canadian Organic Ingredient Strategy was funded by:

CANADIAN AGRICULTURAL PARTNERSHIP

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Lesson 2, Part 1: Seeds and Seeding for Organic Agriculture

There are many factors to consider when selecting seed and seeding methods. These issues include:

Seed choice

- Crop cultivar selection
- Seed size
- Germination rates

Seeding methods

- Seeding rates
- Seeding depth

Intercropping and cover crops

Photo Credit: Marla Carlson

Seed choice

Cultivar (variety) selection

When selecting a variety, consider:

- Market class
- Yield and quality
- Days to maturity
- Disease resistance
- Height

Selecting a variety for organic production requires considering many factors, though one of the most important is disease resistance. Since organic farmers cannot rely on synthetic pesticides to control disease during the growing season, it is very important to select varieties with genetic resistance to disease.

Information on disease resistance and other characteristics is available in provincial seed guides. The example below shows characteristics of oat varieties for Manitoba (Seed Manitoba). The table contains information on yield, maturity, height, test weight and disease resistance for various varieties. Conventional farmers may choose to grow a variety with high yield potential and low disease resistance because they can use a fungicide to control the disease (e.g., Camden oat with S, or susceptibility to crown rust). Organic farmers must choose a more disease-resistant type. Resistance to smut, a seed-borne disease, is absolutely critical in organic farming because fungicidal seed treatments are not available.

Variety Descriptions

Variety[1]	Site Years Tested	Yield bu/acre	Maturity +/- 96 days	Height +/- 84 cm	Test Wt +/- 39.3 lb/bu	Hull %	Hull Colour	Resistance to: Lodging	Smut	Crown Rust	Stem[2] Rust	BYD[3]
AAC Justice	37	154	0	5	0.5	22.8	White	G	R	I	I	I
AAC Kongsore	4	145	1	20	1.0	24.5	White/Light Grey	G	R	MS	I	R
AC Morgan	36	144	-1	15	-1.0	25.2	White	G	I	S	S	MS
CDC Arborg	25	155	-2	19	0.2	20.5	White	VG	R	I	S	S
CDC Big Brown	42	142	-1	3	0	20.4	Tan	G	R	R	MS	MS
CDC Dancer	40	137	-3	13	0.5	19.6	White	G	R	I	I	MS
CDC Endure	14	157	-1	13	-1.1	20.9	White	VG	R	MR	S	I
CDC Haymaker (F)	37	125	2	25	-1.0	22.0	White	G	MR	S	S	—
CDC Minstrel	46	146	0	8	-0.2	22.3	White	VG	R	MS	I	MS
CDC Morrison	13	134	-2	-3	-1.0	24.4	White	VG	R	MS	I	I
CDC Norseman	31	149	-3	5	-1.0	20.5	White	G	MS	MR	S	I
CDC Ruffian	39	150	0	0	-0.8	20.5	White	G	R	I	S	S
CDC Skye	6	138	-2	11	0.5	19.6	White	G	R	R	S	—
CS Camden	34	157	2	0	-1.5	21.1	White	VG	I	MS	S	S
Furlong	72	136	-1	20	0.5	20.3	Tan	G	R	S	I	MR
HiFi	62	144	-3	15	0	24.7	White	G	MS	I	I	MR
Jordan	52	146	2	8	-2.0	23.6	White	VG	R	I	I	MR
Leggett	144	142	0	0	0	23.0	White	G	R	R	I	MS
ORe3541M	25	141	-2	-2	0.6	23.3	White	VG	R	R	S	MS
ORe3542M	25	143	-1	-2	-1.1	24.4	White	VG	R	R	S	S
Pinnacle	50	153	3	10	-1.2	23.7	White	G	R	S	I	MS
Ronald	45	135	0	3	0	22.1	White	VG	R	S	I	MR
Souris	60	141	-4	0	0.5	20.9	White	G	R	MS	MR	MS
Stride	39	141	-2	13	0.6	23.7	White	VG	R	R	I	I
Summit	62	148	0	-3	0.5	20.8	White	G	R	I	I	I
Triactor	43	160	-1	8	-1.5	22.1	White	VG	I	MR	S	MS
Varieties being tested for adaptability in Western Canada												
Akina	41	155	-4	0	0.8	25.6	White	G	R	R	—	—
Bradley	30	140	2	8	—	21.7	White	G	R	MS	MS	MS
Kara	41	154	-3	-3	1.6	26.3	White	G	MR	MR	—	—
Kyron	14	153	-3	3	0.9	26.6	White	G	—	—	—	—
Varieties supported for registration												
CFA1502	14	157	1	1	1.0	28.0	White	G	—	MR	—	MR
OT2122	6	155	-2	11	-1.0	25.9	—	G	R	I	I	I
GRAND MEAN (bu/acre)		146										
LSD (bu/acre) (0.05)		8										

AAC Kongsore was bred under entirely organic conditions specifically for the organic market. AAC Kongsore also shows "R" or resistance to smut. Another consideration when choosing seed for organic production is height. Taller plants can often compete better with weeds. Whereas many conventional growers prefer shorter varieties, organic producers often choose tall varieties. Notice that AAC Kongsore is among the taller oat varieties in the Table.

Voices from the Field: Haywire Farms

At Haywire Farms in Alberta, Titanium hard red spring wheat is the main cash crop, just as it was when the farm was conventional. Before transition, the farmers chose the variety for its milling characteristics. Later, on an Organic Alberta field day, Trevor Riehl learned that tall grain varieties are recommended for organic production because of their ability to suppress weeds. He describes the fact they were growing one of the tallest varieties as a "happy accident." They use a slightly higher seeding rate than when they were conventional, aiming for 32 plants/ft^2.

The wheat is underseeded with cover crops at a cost of about $10-$15/acre (seeding rate: 2-2.5lbs/ac). At first, they seeded cover crops with an air seeder set at ½-inch deep a few days after wheat. Lately, they have been using post-emergent harrowing before broadcasting phacelia and Dutch white clover and harrowing again three or four days later.

In this 18-minute podcast (also available as a pdf), learn about how oat varieties have been bred for organic production in the Canadian prairies, in English and in French.

Seedborne diseases and seed testing

If organic farmers save their own seed for planting, the seed should be tested for germination, vigour and especially seed-borne disease. Accredited seed test labs provide this service and can be located at: Crop Diagnostic Services - Agriculture.

"The main target diseases which could pose a real threat are bunt (*Tilletia tritici*) and glume blotch (*Stagonospora nodorum*) in wheat; leaf stripe (*Drechslera graminea*), net blotch (*D. teres*) and loose smut (*Ustilago nuda f sp hordei*) in barley; loose smut (*Ustilago avenae*) and leaf spot (*D. avenae*) in oats; and *Ascochyta* spp in peas. In addition, ergot, *Fusarium* spp and *Microdochium nivale* must also be considered potential problems for most or all of the cereal species. Bunt, Septoria and Fusarium have been found in organic wheat seed. In Germany in the 1980s, 25-30% of organic wheat seed was rejected due to bunt contamination and in Denmark, about half of all seed lots destined for organic use are discarded on the basis of seed-borne disease levels."[1]

[1] Organic Seed Treatments

To reduce seed-borne diseases, seed growers can treat the seed using plant extracts, physical treatment (hot water or steam) or biological agents. To learn more about seed treatment trials for organic barley, see here.

For a general discussion of organic seed treatments, coating and pelleting, see here (note, however, this publication is focused on vegetable seed production).

Voices from the Field: Upland Organics

At Upland Organics in Southern Saskatchewan, Allison Squires and Cody Straza soak seeds in compost tea before planting. The coated seeds germinate several days earlier than untreated ones and are more vigorous. The beneficial microorganisms [in the compost tea] can help the plants as they grow by improving their access to nutrients and water, something particularly valuable in the dry summer months. The farmers' next step is to add a liquid kit to the seed drill so that they can add compost tea in the furrow next to the seed, so more beneficial organisms are available to the plants as they germinate and grow.

Seed size: are big seeds better?

Using larger seeds has various benefits. This has been seen in almost all crop species, including for small-seeded crops such as canola and mustard.

Compared to smaller seeds of the same variety, larger seeds can:
- Become established more quickly
- Grow taller
- Be more competitive with weeds (largely due to rapid establishment and greater height)
- Acquire more nutrients and light

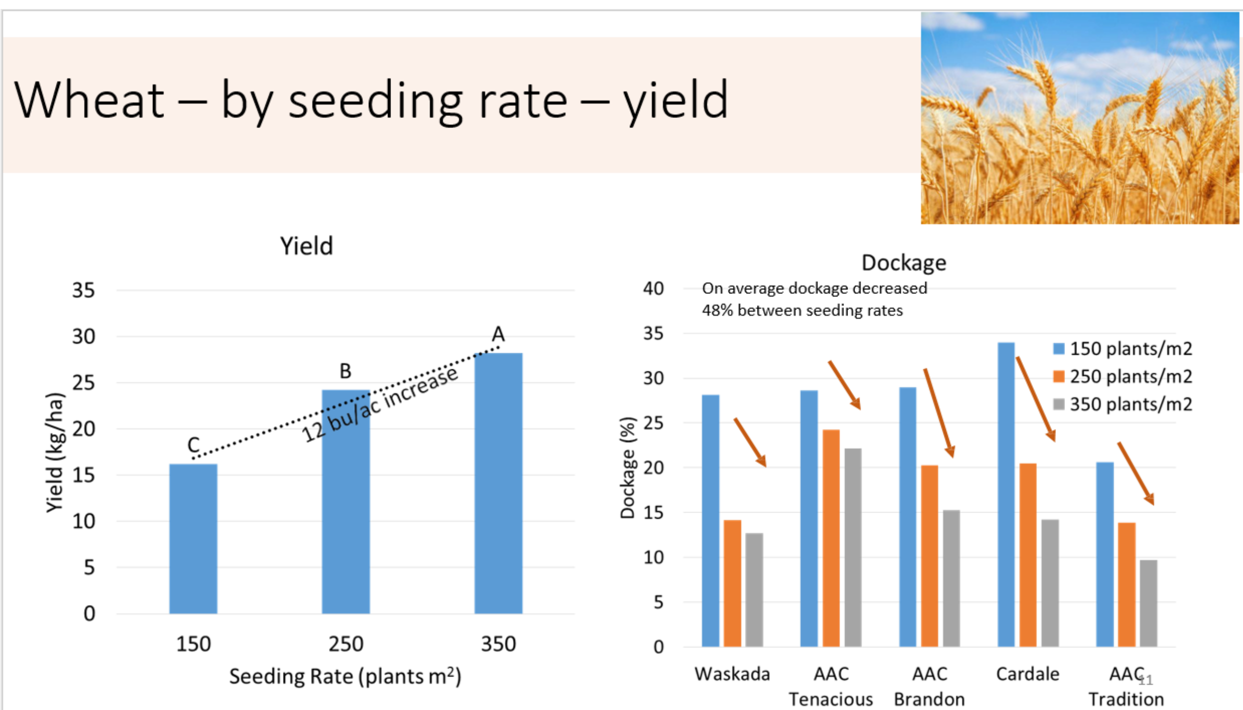
When comparing different size seeds, researchers have found:
- Barley plots seeded with large kernels had yields 12% greater than plots sown with small barley kernels.
- Crops grown from large oat seed had greater yields, lower weed growth and less dockage than crops from small oat seeds.
- Wheat with a greater thousand kernel weight (TKW) compared to smaller TKW produced an 18% greater yield.

- Using larger seed means using a greater amount of seed for a field. One question therefore regards the economics of planting a larger volume of seed compared with a smaller volume of seed. This seems to pay off with a ten-to-one return. For every 1 kg/ha investment in oat and barley seed, the average grain yield was 10 kg/ha greater.[2] (Specifically, with barley, an investment in an extra 65 or 43 kg/ha of seed resulted in a grain yield increase of 871 and 339 kg/ha for the two years. For oats, an investment of an extra 56 and 47 kg/ha of seed resulted in grain yield increases of 607 and 277 kg/ha for the two years.

Seeding methods

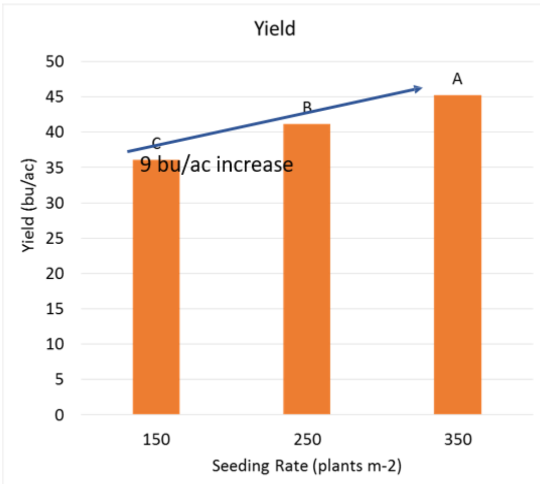
Seeding Rate

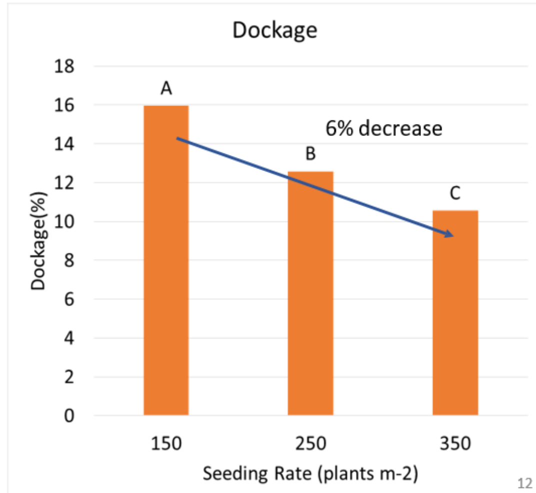
Organic farmers often use higher seeding rates than conventional farmers. One of the most important benefits of high seeding rates is weed control. High seeding rates improve the ability of the crop (as a whole) to compete with weeds. In a study from the Natural Systems Agriculture Lab at University of Manitoba, low seeding rates result in lower yields of organic wheat, barley and oats, as shown below. For all three crops, a seeding rate of 350 plants/m^2 gave the highest yield.



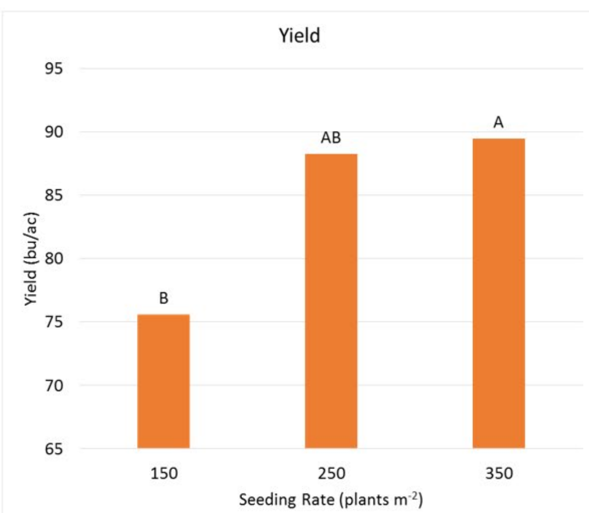
[2] Stanley, K.A. and Entz, M.H., 2019. Can large seed size compensate for deep seeding in organic barley (Hordeum vulgare) and oat (Avena sativa) production? An assessment of farm-saved seed. *Organic Agriculture*, *9*(4), pp.373-381.

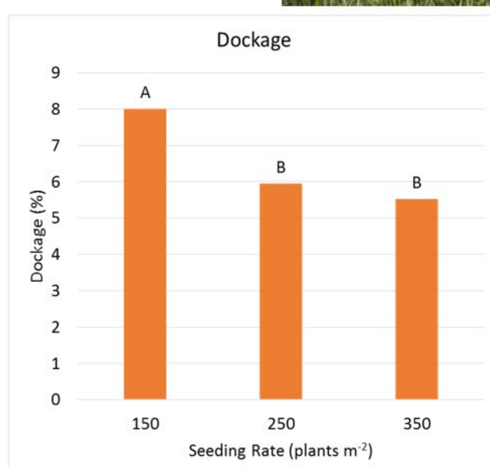
Barley – by seeding rate





Oat – by seeding rate





High seeding rates lead to a greater biomass of the crop and lower biomass of the weeds (the biomass is the weight of the plant material). At the University of Saskatchewan, researchers found that as pea seeding rates increased, crop biomass increased and weed biomass decreased (see below).[3]

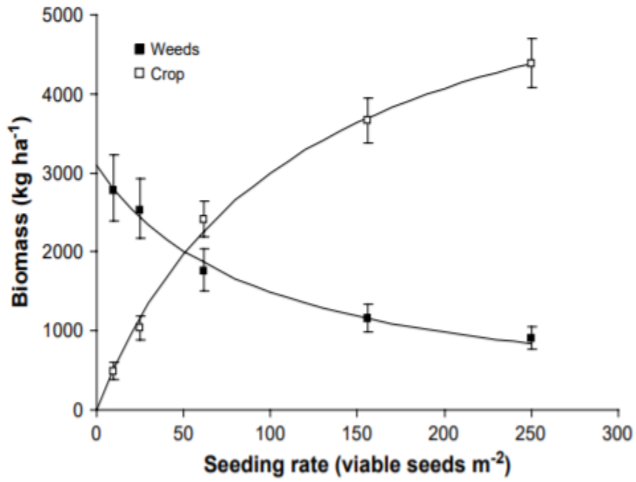


Fig. 2. The effect of seeding rate of pea on weed biomass. Points represent the mean of 4 site-years. Bars indicate standard error of the means.

Dense crops = fewer weeds

Organic farmers have many weed control options, but having a dense crop might be the most effective way to control weeds. When researchers compared the effect of various methods to control weeds in oats, they found that high crop density (the result of high seeding rates) suppressed weeds more effectively than in-crop harrowing, choosing a more competitive variety or using close row spacing.[4] (Harrowing was the second most effective method but the best weed control came from a combination of weed control methods – using a competitive variety at increased seeding rate along with post-emergence harrowing decreased weed biomass by 71% compared with standard practices.)

Seeding Depth

The best general recommendation for seeding depth is that seeds should be planted as shallow as possible, but into moist soil. Because organic agriculture usually requires pre-

[3] Baird, J.M., Walley, F.L. and Shirtliffe, S.J., 2009. Optimal seeding rate for organic production of field pea in the northern Great Plains. *Canadian journal of plant science*, *89*(3), pp.455-464.

[4] Benaragama, D. and Shirtliffe, S.J., 2013. Integrating cultural and mechanical methods for additive weed control in organic systems. *Agronomy Journal*, *105*(6), pp.1728-1734.

seeding tillage for weed control, organic seedbeds may be drier than conventionally farmed seedbeds, where pre-seeding tillage might be replaced by herbicides.

Research on oats and barley at Carman, Manitoba, compared shallow (2.5 cm) vs deep seeding (5 cm). Shallow seeding resulted in more plants per square metre, less weed biomass, a higher grain yield and less dockage. In this experiment, researchers tested whether the negative effects of deeper seeding could be overcome with using larger seeds. It did not but they found that using larger seeds improved yields compared to using smaller seeds, and shallow seeding led to greater yields than deeper seeding.[5]

Inoculation

Legumes have the ability to form a mutually beneficial (symbiotic) relationship with certain soil bacteria - genus *Rhizobia*. *Rhizobia* bacteria are quite specific to which legumes they infect. Below, the type or types of legume followed by the type of Rhizobium that infects those legumes are listed:

- Alfalfa and sweetclover: *Rhizobium meliloti*;
- Red clover, white clover, alsike clover and other "true clovers": *R. trifolii*;
- Peas and vetch: *R. leguminosarum*;
- Birdsfoot trefoil: *R. loti*;
- Soybean: *Bradyrhizobium japonicum*

[5] Stanley, K.A. and Entz, M.H., 2019. Can large seed size compensate for deep seeding in organic barley (Hordeum vulgare) and oat (Avena sativa) production? An assessment of farm-saved seed. *Organic Agriculture*, *9*(4), pp.373-381.

A dramatic example of the effects of inoculation can be seen in the photo above. Alfalfa that was properly inoculated is on the left and right, with alfalfa that was not properly inoculated in the centre. More information on inoculating legumes is available here.

Before buying inoculant, check the label to ensure it will inoculate the appropriate species, check the expiry date and make sure it has been kept cool. (Rhizobia are living organisms). Certified organic farmers should also make sure that neither the inoculant nor sticky agents contain any prohibited substances, such as GMOs. Always check with your certification body for compliance before using any innoculant.

Intercropping and Cover Crops

Intercropping

Intercropping is growing two crops, sometimes called "companion crops," in the field at the same time. They could be seeded in the same row or separate rows, and could be seeded at the same time or one overseeded after the other is already established.

Why intercrop?

- Intercropping adds diversity to the crop rotation and can increase the total revenue per acre.
- Intercrops often provide a more thorough ground cover than monocrops and this can improve soil quality and inhibit weeds.
- Intercropping can also reduce the incidence of disease and pest problems. It's also a form of 'biological crop insurance' – if one crop fails due to pests or extreme weather, the other crop might still provide a harvest.

Examples of successful intercrops include oats and peas, barley and peas, mustard and lentils, flax and wheat, flax and chickpeas and corn and soybeans.

To hear about how Scott Chalmers has used intercropping in Manitoba, check out this 45-minute podcast.

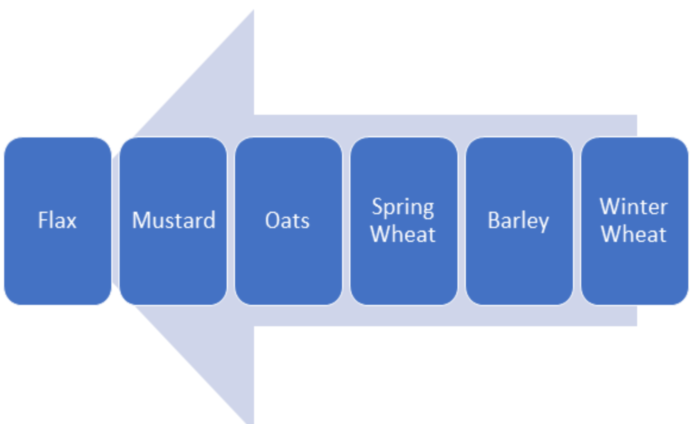
Consider crop height when looking at different crop types and varieties for intercrop production. If seeding canola or mustard with a pulse, for example, the pulse needs to grow as nearly as high as the top of the canola/mustard leaves.

"For lentils, I want a tall, lanky lentil that lodges like mad in order to pair it with an intercrop," says Lana Shaw of the South East Research Farm near Redvers, Saskatchewan. Shaw says crop height considerations are partly about shading. If farmers are intercropping a shorter pulse, they must lower the seeding rate of the taller crop, so the short one gets enough light. You can read more about this particular intercrop here.

Voices from the Field: Haywire Farms

At Haywire Farms outside Leduc, Alberta, Trevor Riehl and Ryan Carroll and Bill Riehl intercrop Amarillo yellow peas and Xena barley. They tried using oats and peas but in wet years, the peas mature far earlier than oats. In contrast, peas and barley ripen at the same time, are harvested together and then separated.

Consider also the competitiveness of the intercrops. From least to most competitive (left to right):



Seeding rates of intercrop partner crops vary greatly depending on the purpose of the intercrop. For example, if an oat-pea intercrop is designed mainly for pea production and oats are included only to provide some structure to the crop canopy, then the seeding rate of pea may remain “normal” while a reduced seeding rate is used for the oats. On the other hand, in a lentil-flax intercrop the goal may be to have equal numbers of lentil and flax plants. In this case, each crop may be seeded at 60% or more of its normal seeding rate.

This is an example of a pulse crop-mustard intercrops in south-east Saskatchewan. Mustard was seeded at 3.5 kg/ha (3.1 lb/ac) in the intercrop and 6.2 kg/ha (5.5 lb/ac) when seeded alone as a monocrop. The seeding rate of pulse crops was reduced by approximately 30% in the intercrop compared with the monocrop; they were set to target plant populations of 130 and 70 plants/m^2 for monocrop peas and lentils and 98 and 53 plants/m^2 for peas and lentils intercropped with mustard.

The decision on whether to place all intercrop seeds in the same planting row, or in two different rows depends on the equipment availability and on the crops involved. Farmers use many different row configurations for grain intercrop production.

Example: Derek Axten's farm in Minton, Saskatchewan. On this farm, all the crops are seeded as mixed rows except flax and chickpea, which are seeded in alternating rows in 20-inch spacing. This helps delay canopy closure and allows for more air movement later into the season. To learn more, see here.

Intercropping Resources

Find a list of intercropping resources at Intercropping | Pivot and Grow.

Seeding forages and cover crops

Seeding forage and cover crops may require some special consideration while seeding. This is especially true for small-seeded species such as alfalfa, clovers, and other small-seeded annuals (e.g., turnip, radish, etc.). Details on forage establishment can be accessed from a presentation by the Beef Cattle Research Council.

One special consideration is weed control. How do farmers establish small-seeded crops like alfalfa or clover without using herbicides? Management practices which can improve establishment success or organic forages include:

- Use a companion crop along with the small-seeded forage (e.g., oats can be a nurse crop for alfalfa)
- Mow weeds after the forage has successfully established
- Ensure the soil can provide adequate nutrients to allow the forage crop to grow well.

For more information on cover crops, see here.

Voices from the Field: Marshall Farms

On Marshall Farms, to provide nitrogen in the rotation, the Marshalls intercrop alfalfa with hemp. In the same seeding pass, they seed 10 pounds/acre of alfalfa in the same row as 30 pounds of hemp. If there's a problem with a hardpan, they might add chicory to the mix. "In the fall, when the hemp comes off, those little young alfalfa plants get sun and keep growing," Larry says. If they want a green manure, they incorporate the alfalfa in late July the following year and get 100 pounds of nitrogen per acre.

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To learn more about the Prairie Organic Development Fund www.organicdevelopmentfund.org

For more Organic Production Resources www.pivotandgrow.com

The Prairie Organic Development Fund (PODF) is an investment platform established to develop organic agriculture and marketing in the Canadian Prairies. PODF builds resilience by investing in organic provincial associations (Capacity Fund) and high impact programs (Innovation Fund) related to marketing, research, policy, education and capacity development that have broad public benefit to the organic sector. The fund is directed by a board made up of organic producers, grain buyers, organic brands, researchers and provincial organizations.

The **Canadian Organic Ingredient Strategy (COIS)** provides farmers with tools and support to incorporate organic farming practices that help meet the growing demand for organic foods in Canada. The tools developed as part of this project will help Canadian farmers benefit from increased knowledge and skills in organic farming methods, which can improve soil health and boost farm resilience in the face of changing markets and climate change.

Visit www.pivotandgrow.com to learn more about the tools created as part of COIS.