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Management of organic hairy vetch (*Vicia villosa*) cover crops in the establishment year

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Keywords: Planting date; seed source; weed suppression

Field studies showed that Hairy vetch (*Vicia villosa*) of 'northern origin' produced more biomass than cultivars developed in milder climates. Hairy vetch biomass was greatest and weed biomass was lowest when vetch was planted in spring vs mid-summer. Approximately 50 plants m⁻² maximized hairy vetch biomass production and weed suppression.

Hairy vetch (*Vicia villosa*) is a plant of interest in organic production (USDA 2011) since it fixes high levels of N and provides weed suppression by forming surface mulch. The mulch provided by hairy vetch has facilitated organic no-till grain crop production (Halde et al. 2015). Hairy vetch was first described in Manitoba in the late 1800s at the "Experimental Farm for Manitoba" (Brandon Research Farm) where the plant was described to have "a very spreading habit and would have been difficult to harvest" (Bedford 1900).

Spring planted hairy vetch results in large amounts of biomass (Halde et al. 2015) making it an excellent full-season legume cover crop; full season cover crops are typically used in Canadian prairie organic production (Entz et al. 2001), though hairy vetch use is still limited.

Spring planted vetch in the prairie region withstands blade rolling in the year of establishment (Halde et al. 2015), which allows selective control of annual weeds that establish alongside the vetch. Hairy vetch then winterkills, resulting in dead mulch for no-till seeding the following spring (Halde et al. 2015).

The prairie system of using a full-season legume cover crop differs from longer season regions, such as parts of eastern Canada. In the US Mid-Atlantic region, for example, hairy vetch is often planted in late summer after crop harvest (USDA, 2011; Maul et al. 2011). Under these conditions, hairy vetch survives the winter, and blade rolling has been used to kill vetch plants before organic crop (eg., corn *Zea mays*) planting the following spring (Mirsky et al. 2009). No previous studies on fall planted hairy vetch have been conducted in the prairie region, and so the first objective of this study was to determine growth and overwinter survival when planting hairy vetch at different times of the year.

Previous research on the role of hairy vetch in organic no-till in Canada (Halde et al. 2015) was conducted with one “northern origin” hairy vetch genotype, yet genetic variation in hairy vetch exists (Maul et al. 2011). Therefore, a second objective was to compare different hairy vetch genotypes, in particular how vetches of “northern origin” compare with genotypes developed for milder climates (USDA, 2011). The final objective regards hairy vetch seeding rates because at presently recommended rates (approximately 25 kg seed ha⁻¹), hairy vetch is among the most expensive legume cover crop options. Mirsky et al. (2012) tested different ratios of hairy vetch and triticale (*Triticale* ($\times$ *Triticosecale*)) in fall-planted system, however to our knowledge, no previous study has considered seeding rate with full-season hairy vetch systems.

Field experiments were conducted for two years at Carman, Manitoba. The Chernozemic soil was from the Hochfeld series (Mills and Haluschak 1993) and vetch experiments were preceded by barley (2011) or oat (2012) silage crops. Experiment 1 consisted of 5 hairy vetch genotypes seeded at 3 different times of year (early spring - May 13 and 16, 2012 and 2013, respectively; mid-summer – July 17 and 12, 2012 and 2013 respectively; and early autumn – September 6 and August 30, 2012 and 2013, respectively). The experiment was arranged in a split plot with seeding date as the mainplot and genotype as the subplot. Four replicates were used. Two genotypes of “northern origin” were tested. The first was produced in central Minnesota (sourced from Albert Lea Seeds, Albert Lea, Minnesota; referred to as ‘MN’). Seed of ‘MN’ was produced at the University of Manitoba farm and is referred to as ‘MB’. Other genotypes were hairy vetches produced in Oregon (sourced from Homestead Organics, Berwick, Ontario; referred to as ‘Oregon’) and Washington State (sourced from Pickseed, Winnipeg, Manitoba, referred to as ‘Washington’). Two cultivars developed at USDA in Maryland (Purple prosperity and Purple bounty) were also included in the study. Hairy vetch genotypes of northern origin may have originated from the cultivar Madison, the only *Vicia villosa* ssp. *villosa* accession entry in the U.S. National Plant Germplasm System (2016). Madison has greater winter survival and more trichomes on the leaves and stems (Nicholas Wiering, University of Minnesota, pers. comm.). In the present study, ‘MN’ and ‘MB’ did indeed show more hairiness (more trichomes) than all other lines (K. Bamford, field observations).

All plots were seeded with a seed drill (Fabro Industries, Swift Current, Saskatchewan) at a depth of 1.5 cm and 15 cm row spacing. Plot size dimensions were 1.8 m (12 rows) by 10 m. Seeds were inoculated with a granular pea (*Pisum sativa*) inoculant (EMD Crop BioScience Inc.). Plant population density was measured in 1 m length of row randomly selected within

each plot 28 days after planting. An estimation of flowering was conducted visually with 1= no flowers and 5 = 100% of plants having flowers. Aboveground vetch and weed biomass were measured from 2, 0.25 m² samples per plot harvested at intervals (or just once) during the growing season. Weeds were separated from crop biomass, and both were dried at 80 C for 48 hours before weight measurement. In the first year of experiment one, aboveground biomass and plant density was measured for surviving plants in the early autumn seeding date treatment the following spring.

Experiment two compared four different planting densities. The factorial experiment included 4 seeding rates (30, 60, 90 and 120 live seeds m⁻²), 2 vetch genotypes (Purple prosperity and Oregon) and was replicated 4 times. Crops were seeded on May 23 in both years. Plant population density was measured approximately 4 weeks after seeding using the procedure described for experiment one. Total vetch and weed biomass were measured in mid-August in both years and again in late fall using the procedure outlined for experiment one.

Hairy vetch establishment was generally highest with earlier planting (Table 1). Lower plant establishment with later planting was attributed to hotter and dryer soil conditions in mid-summer. No genotype effect was observed in 2012. A genotype x seeding date interaction in 2013 was due to Purple bounty and 'Oregon' having lower plant population density than all other varieties at the mid-summer seeding date with no genotype differences on the other dates. Flowering measurements taken in July (2013 only) indicated that the two cultivars, Purple bounty and Purple prosperity, had close to 100% of plants producing flowers while all other varieties had almost no flowers. Therefore, Purple bounty and Purple prosperity appear to be the only cultivars tested that were vernalized under the conditions of this study.

Biomass production measured at the end of the growing season was greatest for the early spring seeded vetch in both years (Table 1). Halde et al. (2015) determined that 7000 kg ha⁻¹ of hairy vetch biomass was required to provide sufficient weed suppression for no-till organic seeding the following year. Only 'MB' and 'MN' seeded in early spring provided this amount of biomass in 2012 (Table 1). Biomass values were higher in 2013 due partly to more late season precipitation. Purple bounty had significantly less biomass than most other genotypes and Purple prosperity had less biomass than 'MB'.

End of season biomass for the early autumn plantings was not collected in 2012 since drought limited plant growth after establishment. Under more favourable late-season precipitation conditions in 2013, early autumn seeded hairy vetch plants still produced less than 200 kg biomass ha⁻¹. It appears that early spring planting will maximize hairy vetch biomass production.

Late-autumn weed biomass was measured for early spring and mid-summer (2013 only) plantings. Major weeds in both years were redroot pigweed (*Amaranthus retroflexus*), green foxtail (*Setaria viridis*) and yellow foxtail (*Setaria glauca* (L.) Beauv.). Where differences were observed, the lower biomass yielding Purple prosperity and Purple bounty had significantly more weed biomass than higher yielding 'MB' and 'MN' (Table 1). This demonstrates the value of genotype selection as a possible weed management strategy in hairy vetch cover crop production.

Over-winter survival was observed only for the early-autumn seeded treatment since early spring and mid-summer plantings did not survive the winter regardless of genotype. For the early autumn planting, very few plants of varieties other than 'MN' and 'MB' survived (Table 1, 2013; visual observations only in spring, 2014, data not shown). Seed yields taken in

August 23, 2014 from the surviving fall seeded plots showed that 'MN' and 'MB' produced 547 and 471 kg ha⁻¹, respectively (data not shown). To our knowledge, hairy vetch cover crop seed yields have not been previously reported in Canada. If growers choose to seed 'MN' or 'MB' late in the season and do not want seed production, these hairy vetch plants will have to be terminated before seed set, which typically begins in late June.

As expected, increasing seeding rate increased hairy vetch plant population density in both years (Table 2). Hairy vetch biomass was affected by seeding rate in all cases where it was measured; two dates in 2012 and one date in 2013 (Table 2). In 2012, the two highest seeding rates (90 and 120 seeds ha⁻¹) had significantly more biomass than the two lowest rates (30 and 60 seeds ha⁻¹) while in 2013, only the lowest seeding rate resulted in lower vetch biomass (Table 2). In both years, the highest seeding rates provided biomass levels close to 7000 kg ha⁻¹, the minimum level for weed suppression (Halde et al. 2015). No differences between genotypes ('Oregon' and Purple prosperity) were observed, nor were any genotype x seeding rate interactions recorded (Table 2).

Across all treatments and sites, plant population density was positively correlated with hairy vetch biomass ($r = 0.84$; $p = 0.0088$). It was determined that greater than 50 hairy vetch plants m⁻² were required for maximum hairy vetch biomass production (data not shown).

Weed biomass was significantly reduced with increased seeding rate in both years (Table 2). The magnitude of the difference in weed biomass between low and high seeding rates was much greater in 2013 than 2012. It may be that the lower overall weed biomass in 2013 allowed hairy vetch at the higher seeding rates to be more competitive. Hairy vetch plant population and weed biomass were negatively correlated ($r = -0.38$; $p = 0.0143$) indicating that seeding rate is a possible weed management strategy in hairy vetch cover crop production.

It was interesting to observe that hairy vetch biomass for the two highest seeding rates was similar (6489 kg ha^{-1} in 2012 and 6752 kg ha^{-1} in 2013) despite large differences in weed biomass; 4751 kg ha^{-1} in 2012 compared with 285 kg ha^{-1} in 2013 (Table 2). This observation suggests significant weed tolerance for hairy vetch, something that was previously observed (Halde et al. 2015). These authors observed significant hairy vetch growth in late summer and autumn, even under weedy conditions. They attributed this aggressive hairy vetch growth to its viney nature, a trait that had been observed by Bedford (1900) over 100 years earlier, and the competitive advantage of the N-fixing ability of hairy vetch against non-fixing weeds.

This preliminary study showed that 1) greater than 50 hairy vetch plants m^{-2} were required for maximum biomass yield, 2) delaying planting date to late summer increased overwinter survival and 3) growers should select genotypes of 'northern origin' if seeking overwinter survival.

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Table 1. Effect of seeding date and genotype on hairy vetch establishment, flowering, biomass, and weed biomass production at Carman, MB in 2012/13 and 2013.

		2012-2013					2013		
		Biomass 2012 Nov 16					Biomass 2013 Oct 9		
Seeding date (D)	Genotype (source) ^a	Plant density	Flowering ^c	Hairy	Weeds	Plant density2013	Plant density	Hairy	Weeds
		28 DAP ^b	2012 Jul 17	vetch		May 15	28 DAP	vetch	
		plants m ⁻²		----- kg ha ⁻¹ -----		plants m ⁻²	plants m ⁻²	----- kg ha ⁻¹ -----	
Mid-May	Oregon	66.9	1.00b	4163b	7040ab		63	7241ab	698
	Wash.	55.3	1.25b	4312b	6374b		67	6894ab	493
	PP	55.3	3.25a	3925b	8289a		59	6079bc	757
	PB	66.9	4.00a	1578c	8312a		68	4668c	909
	MB	52.5	1.25b	6697a	5823b		64	7938a	180
	MN	66.9	1.25b	7081a	5655b		63	6950ab	462
	avg.	60.6	2.00	4626	6915		64	6628	583b
	<i>Pr > F</i>	<i>genotype</i>			0.0002		<i>ns</i>	0.0055	<i>ns</i>
Mid-summer	Oregon	51.9		700b			60c	1328ab	2116
	Wash.	55.3		888b			69b	1560ab	1862
	PP	49.1		673b			73b	1704a	1780
	PB	51.6		406b			58c	1458ab	1788
	MB	53.4		573b			88a	1217bc	1899
	MN	57.5		1539a			53c	950c	2061
	avg.	53.1		796			67	1370	1918a
	<i>Pr > F</i>	<i>genotype</i>			0.0064		<.00001	0.0099	<i>ns</i>
Early autumn	Oregon	41.7				2.0b	34	102	-
	Wash.	43.9				1.3b	35	111	-
	PP	46.1				1.3b	42	153	-
	PB	41.1				0.7b	36	129	-
	MB	55.0				22.0a	40	183	-
	MN	40.0				19.3a	32	139	-
	avg.	44.6				7.3	37	136	-
	<i>Pr > F</i>	<i>genotype</i>					<i>ns</i>	<i>ns</i>	-
<i>Pr > F</i>	<i>D</i>	0.0105		0.0226			0.0002	<.0001	0.0181
	<i>Genotype</i>	0.8631	<.0001	<.0001	0.0038	<.0001	<.0001	<.0001	<i>ns</i>
	<i>D*genoty</i>	0.1084		0.0001			<.0001	<.0001	-
	<i>pe</i>								

Note: Means with a column not sharing a common lowercase italic letter differ significantly at the $P < 0.05$ level.

^a Genotype (source): Oregon - Oregon grown; Wash. - Washington grown; PB - Purple Bounty; PP - Purple Prosperity; MB - Manitoba grown; MN - Minnesota grown.

^b Days after planting.

^c Flowering - 1 to 5 rating with 1=no flowers and 5=100% flowers.

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Table 2. Effect of seeding rate and genotype on hairy vetch establishment, biomass, and weed biomass production at Carman, MB in 2012 and 2013.

Genotype (G) ^a	Seeding rate ^{by} PLS m ⁻²	2012					2013		
		Plant density plants m ⁻²	Biomass, Aug 21		Biomass, Oct 16		Plant density plants m ⁻²	Biomass, Oct 8	
			Hairy vetch	Weeds	Hairy vetch	Weeds		Hairy vetch	Weeds
			-----	kg ha ⁻¹	-----	-----		-----	kg ha ⁻¹
PP	avg.	48a	729a	3147	4505	5328	56	5475	619
Oregon	avg.	42b	579b	2928	5015	5145	59	6427	477
	30	21d	360b	3415a	2490c	5804	24d	4654b	888a
	60	36c	528b	3075ab	4002b	5546	44c	6073a	576b
	90	53b	837a	2790b	6059a	4844	70b	6327a	423bc
	120	71a	891a	2871b	6489a	4751	92a	6752a	285c
	avg.	45	654	3038	4760	5236	58	5952	548
<i>Pr > F</i>	<i>G</i>	0.0469	0.0053	ns	ns	ns	ns	ns	ns
	<i>Rate</i>	<.0001	0.0017	0.0357	<.0001	ns	<.0001	0.0014	<.001
	<i>G*Rate</i>	ns	ns	ns	ns	ns	ns	ns	ns

Note: Means with a column not sharing a common lowercase italic letter differ significantly at the P<0.05 level.

^a Genotype (source): Oregon - Oregon grown; PP - Purple Prosperity.

^b Seeding rate (pure live seed/m²): Purple Prosperity 30 PLS = 10 kg ha⁻¹ (2012), 9 kg ha⁻¹ (2013); Oregon 30 PLS = 8 kg ha⁻¹ (2012 and 2013).

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