Title: Potential of Biennially Grown Canola and Canola Grown in Other Dryland PNW Environments

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Background: Winter canola has better and more consistent yield potential than spring canola in eastern Washington if good stands can be established and plants have formed a healthy rosette before cold winter temperatures occur (Davis et al. 2008). In irrigated areas sufficient size is generally achieved when planted by mid-September. In the rainfed annual cropping areas, mid-September plantings typically do not have sufficient soil moisture to germinate until fall rains begin. The plants from these later plantings are then very small during early winter and don’t survive the low temperatures. In the low and intermediate rainfall regions winter canola is typically planted into summer fallow land in late August or early September and stands can also be difficult to achieve under these conditions. Canola is poorly suited for deep furrow seeding that has been developed for winter wheat seeded into fallow. Soils are dry and hot and moisture is well below the surface. Unlike the Midwest, rains rarely occur during this period and the seed must be planted very deep to find moisture (13); the combination of deep planting and hot soil temperatures makes stand establishment very inconsistent.

Planting winter canola in late spring or early summer makes stand establishment much easier. This is not a common practice however, so it is difficult to predict how the canola plants will respond to a long period of growth the first summer before vernalization, and how it will affect their ability to survive the winter and perform well the following season. Canola varieties vary in their vernalization requirements, so some ‘winter’ varieties may actually flower the first summer or fall. Canola plants will likely use most of the available water the first summer, and varieties may respond differently in how they are affected by this.

Growing canola as a biennial crop might also present opportunities for other beneficial cropping systems variations like grazing and intercropping. Cropping rotations that include perennial or biennial forages can provide multiple agronomic and environmental benefits which enhance soil tilth and fertility (Russelle et al 2007). In a mixed cropping system where livestock are rotated with cash crops, winter canola can provide an immediate source of high quality forage and a grain crop for oil production the following year while improving the profitability and flexibility of the system (Kirkegaard 2006; Neely et al 2009). Winter canola has been grazed in Oklahoma and Australia but this is typically planted in the fall and grazed in the winter (http://www.canola.okstate.edu/cropproduction/forageproduction/index.htm; Kirkegaard et al., 2008). When winter canola was planted in March or April in Australia and grazed in mid-August, the varieties recovered from grazing to produce 4 tons ha⁻¹ fresh weight; 9.9 tons acre⁻¹ and good (47%) oil content. Oil yield was unaffected by grazing but a later grazing date increased forage production and reduced grain (oil) yield. Canola could be intercropped to enhance its forage quality or possibly to supply nitrogen. Legumes are valuable in intercropping because they fix nitrogen and can thus be used to improve soil fertility without purchasing fertilizer. Legumes have been grown with wheat, without affecting crop yields (Wiersma et al., 2005). Yield reductions could occur when cropped with canola if the crops were competing for limited water, but if the competition is limited to the first year of a biennial crop, this should have a smaller effect.
Incidence of many diseases in canola in Eastern Washington has generally been low. We have not observed black leg, probably the most destructive disease of canola in Canada and the Midwest, (http://www.ag.ndsu.edu/pubs/plantsci/crops/pp1367.pdf), and it has not been reported in Washington. Incidence of Sclerotinia stem rot, (http://www.whitemoldresearch.com/HTML/canola.cfm) another destructive disease in the Midwest, is not common in dryland canola but can be a problem in irrigated canola. Rhizoctonia damping off can be a problem in stand establishment as it can be very destructive in seedlings but can also damage older plants (Paulitz et al., 2002, Huber et al., 1992). In Washington it can be a particular problem in direct seeding, especially when weeds and volunteers are killed near planting time (Paulitz et al., 2002; http://css.wsu.edu/Proceedings/2003/Paulitz_RootDiseases.pdf).

Objectives: Our main objective is to identify conditions where winter canola can be grown more reliably in dryland eastern Washington environments. A secondary objective is to identify varieties or germplasm that are best adapted to these conditions, especially if they are nonconventional environments (e.g. unusual planting times). Germplasm that might be better adapted to these conditions might include accessions that can survive hard freezes as seedlings, germplasm that can survive very dry conditions and then subsequent winters, germplasm that can emerge and survive during very hot dry conditions, or germplasm that is more resistant to any diseases encountered in these conditions.

Methods: Canola lines and varieties were collected from all major canola production regions. These varieties were screened by a variety of lab, greenhouse and field tests. Seedling cold tolerance tests were conducted in programmable refrigeration chambers. Seven to 14 day old seedlings grown at 20°C were placed in the cold chambers for 24 hours. A variety of different cold temperature regimes during this 24 hours were attempted to differentiate the tolerance of different varieties.

Rhizoctonia assays were performed by planting seedlings in Ritzville silt loam infested with 100 ppg of *Rhizoctonia solani* AG8 isolate C1, 50 ppg of *R. solani* AG2-1 isolate 040562 or a non-infested soil as a control. Flats were grown under at 15°C in a growth chamber. The percentage of seedling emergence, hypocotyl rot, shoot length and root length were used as criteria for evaluation.

Field tests of multiple varieties were done in a variety of different planting dates and locations. Plots at Othello were planted after tillage and irrigation. Furrows for irrigation were cut through the plots after seedling emergence. These plantings were done with a small walk-behind planter that plants five rows on a four foot wide plot. One foot was left between plots so the plots were considered to be five feet wide for yield calculations. Other locations were direct seeded into wheat stubble. A direct seed drill was used with row cleaners, a shank that places fertilizer approximately two inches below the seed and double-disk openers. Row cleaners and seed openers were adjusted to reach ½-1 inch into moist soil and packer wheels firmed the soil over the seed. The direct seed drill planted eight rows on eight foot-wide plots. Five rows from the middle of the plots were harvested to harvest samples and determine yield.

Canola and canola-legume intercropping plots were planted in both Pullman and Davenport in 2009. Pullman plantings were on June 10 and July 8 and Davenport plantings on June 8 or July 7. Plot sizes were 8 X 50’ and were planted with either with 21.4 grams of HyClass110RR canola with one foot row spacing (8 rows), 10.6 g canola with 208 g ‘Ariel’ spring peas, or 10.6 G canola with 208 g ‘AC Greenfix’ chickling vetch. In the intercropped plots, the legumes and canola were planted in alternate rows approximately 1 foot apart. Each of the three cropping treatments was replicated four times in a randomized complete block design. After approximately two months growth, ½ of each plot (8 X 25’) was randomly selected and the shoot material was mowed to 3’ tall. The biomass from each ½ plot was weighed and samples were collected and dried to determine dry weight.
**Results:** Growth chamber tests of canola seedlings failed to identify repeatable differences among canola varieties in their resistance to low temperatures. Conditions that killed one variety typically killed all the varieties in each test. To look at differences in Canola genotypes we have planted the varieties in the ‘National Winter Canola Variety Trials’ along with local varieties in each of the last two years. The total number of varieties at each site was between 65 and 100, except for the Davenport 09/10 plots where only 33 varieties that were commercially available were planted. Results of the trials can be accessed here: [http://www.css.wsu.edu/biofuels/final_report_2009/R1_R2_Potential_Bienially_Grown_Canola.pdf](http://www.css.wsu.edu/biofuels/final_report_2009/R1_R2_Potential_Bienially_Grown_Canola.pdf)

As with the growth chamber tests, field tests that were planted late and thus had small plants during the winter typically had poor survival and no differences between varieties were observed for this trait.

Variety trials were planted in 2009 in Davenport to test varietal adaptation to early planting in this region. Ralston was added as an additional site in a summer 2010 planting. Two planting dates were selected, June 8 and July 7. Thirty four varieties were selected which included most of the commercially available material in the PNW and some other material that has shown high yield potential in trials in Othello. The plots were planted into stubble from the previous year’s winter wheat crop. Good stands were established from both planting dates. Plots were scored for premature flowering on October 8. Little if any flowering was observed in any of the July-planted plots, but several varieties showed some premature flowering in the June planting. The varieties Sumner and Wichita showed an estimated 48 and 32% flowering plants. Two Idaho varieties, Erika and Athena, also showed a tendency to flower in this trial, with approximately 18% and 14% flowering, respectively. The other varieties all averaged 10% or less flowering and several had no flowering plants. The stems of many plants were elongated ~2-10 cm but this appeared to be affected as much or more by environment than genotype. Areas of the field that appeared the most drought stressed showed little stem elongation, possibly because the plants had quit growing before they were stimulated to begin flowering.

All varieties in the June 2009 planting showed extensive winter kill with roughly half the plots having no surviving plants in the spring. The variety with the best survival, KS4022, averaged only 12 surviving plants per plot or roughly 1-2% survival. The July-planted plots fared a little better, but survival was still generally poor. Varieties ranged from an estimated average of 2% to 23% survival. A Kansas State University line KS4022 showed the best survival in both planting dates with an estimated 1.5% in the June planting and 23% in the July planting. Other varieties that survived well in the July planting included the University of Idaho varieties Erika (19.3%) and Athena (15.7%). Glyphosate resistant varieties also showed a range of winter hardiness ranging from Monsanto’s DKW45-10 (14.3%) to Croplan’s HyClass110WRR (3.3%). The plots were not harvested for yield because of the large range, and generally poor survival in the plots. Since a single location and year is not sufficient to gauge winter hardiness or other performance attributes, the varieties were planted again at Davenport and Ralston in June and July 2010.

Early planted trials were also established to examine several other cropping systems factors on the performance and utilization of early-planted canola. Factors examined included the effects of intercropping with legumes and the effects of harvesting biomass two months after planting (Table 1). Good stands were achieved with canola monocultures at both locations. Plots with both canola and legumes were established by making two passes through the plots with seed openers spaces at two foot intervals. Legume rows were alternated with canola rows with approximately 12” between the rows. Legumes were planted approximately 5 cm deep and canola approximately 2 cm deep. After the first plantings at both locations, it was apparent that the legumes should be planted first because disturbing the planted canola rows often covers the seed with excess soil, sometimes preventing emergence.
Aphid infestations occurred at both Pullman and Davenport in August, so single applications of Malathion were made in both locations. In 2009, unusually cold fall and winter weather killed all of the canola plants in the canola intercropping plots in Pullman.

**Table 1.** Average yield (lbs/acre) of biomass harvested in a single cutting from each plot approximately two months after planting.

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<thead>
<tr>
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<th>Pullman June</th>
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<th>Davenport June</th>
<th>Davenport July</th>
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<tr>
<td>Canola</td>
<td>5461</td>
<td>11217</td>
<td>2298</td>
<td>2134</td>
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<tr>
<td>Canola/pea</td>
<td>5843</td>
<td>10210</td>
<td>1862</td>
<td>1710</td>
</tr>
<tr>
<td>Canola/vetch</td>
<td>6294</td>
<td>11124</td>
<td>1710</td>
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In greenhouse experiments, we examined resistance to two taxa of *Rhizoctonia solani* (AG2.1 and AG8) among various *Brassica* species and varieties, including nearly 100 winter canola cultivars. No resistance was observed in the camelina varieties, mustard varieties (*B. juncea* or *S. alba*), *B. rapa* canola, or spring *B. napus* canola lines examined. AG2.1 was the most virulent strain and reduced seedling emergence. The effects of AG8 included seedling stunting and post-emergence damping off. While less aggressive, it is very prevalent in the region and also infects wheat. Three *B. napus* winter canola varieties were identified that were more tolerant to the disease. We have made several crosses between resistant and susceptible varieties to look at the inheritance of resistance to this disease. The hybrid cultivars Flash and Sitro, from the German company DSV, and the open-pollinated DeKalb variety CWH688 showed the most tolerance to the two *Rhizoctonia* strains. The resistance in the CWH688 variety is most likely to be true breeding (homozygous) in this variety so we made crosses with this variety. CWH688 was crossed to two susceptible varieties, Wichita and Virginia and two F2 populations were constructed.

We have examined various chemical seed treatments on the incidence of seedling damping-off of canola in the greenhouse, inoculated with *R. solani* AG 2-1. These chemicals included Prosper 400 (thiram, carboxin, and metalaxyl), Helix Xtra (fluidioxonil plus insecticide), and Maxim 4FS (fluidioxonil). But none were effective in reducing damping-off.

**Discussion:**

The project has had little success in identifying canola germplasm with high levels of cold tolerance at the seedling stage. Few repeatable differences between varieties were observed in laboratory tests on seedlings. In addition, late planted trials have indicated that all the commercial varieties tested were sensitive to hard frosts as young plants. Late planted winter canola is therefore not currently a viable option for consistently growing winter canola in the annual cropping regions.

With no effective seed treatments for Rhizoctonia damping off, the most effective control strategies will be to avoid green bridge problems and to develop and use cultivars with good levels of genetic resistance. Since we do not have an active canola breeding program, we will plan to demonstrate and publish the existing sources of resistance.

**Impact/Potential Outcomes:** If our early planted winter canola trials are successful, it will open several important options for canola producers. More consistent stand establishment will take a lot of the risk out of canola production in the intermediate and maybe low rainfall areas. If grazing or biomass harvest does not severely affect canola yields, this may make winter canola attractive in the annual cropping
region, especially to growers that have animals. If legume intercropping does not hurt yields, it may allow growers in the high and intermediate rainfall regions reduce input costs.

Methods for reliable production of winter canola would not only benefit the biofuels industry, but would make our wheat based cropping systems more sustainable. Including canola in rotations with wheat can facilitate weed control and provide other rotation benefits and thereby increase overall profitability (Guy and Karrow 1998; Helm and Hansen 2008; Herdrich 2001; Painter et al. 2009).

Publications: none yet

Future directions in the upcoming year:

Our field experiments will focus on the early planted (biennial) canola. We will collect yield and survival data on the variety trials planted in Davenport and Ralston and replant selected varieties.

References:


