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Varieties and Pre Harvesting Treatment for Growing Polish Canola (*Brassica rapa* L.) in Interior Alaska

Mingchu Zhang*, R. Van Veldhuizen

Department of Agriculture and Horticulture, School of Natural Resources and Extension, University of Alaska Fairbanks, USA

Abstract Barley has been a mono cereal crop grown in the Delta Junction area of Alaska since 1970s. A rotational crop is needed for weed control and conservation tillage for sustainable crop production. Due to short growing season constrains, canola when used as a rotational crop currently resulted low marketability because of high green seed content (>2%). The objective of this research is to determine if glyphosate when used as a desiccating chemical could promote early maturity and reduce green seed content of canola. Four Polish canola cultivars were treated with direct combine (as a control), pushing (to stop growth) and desiccating in two locations in Alaska USA in a randomized complete block design with four replicates from 2007 to 2009. Glyphosate was sprayed, and pushing was conducted around August 15 each year. Results showed that 'Hysin 110' treated by glyphosate consistently had ≤ 2% green seed content in three years in contrast with 'Reward' despite a wide variation of weather conditions. The growing degree days were dramatically different among the three years, with 2009 close to the 29-year norm, 2008 was lower and 2007 was higher than the norm. No residual glyphosate was found in the seeds from the desiccating treatment. In conclusion, desiccating treatment together with a good short growing season Polish canola cultivar can make canola grown as a rotational crop in Alaska's short growing season conditions.

Keywords *Brassica rapa*, Polish Canola, Pre-harvest Treatments, Glyphosate, Alaska, Oil Quality

1. Introduction

Barley (*Hordeum vulgare* L) has been grown in the Delta Junction area (64°49' N, 147°52'W) of Alaska since land conversion to agriculture in the 1970s. The soils in the area are predominantly silt loams formed from glacial rock flour and re-deposited by wind and water. Clay content in soils usually is less than 10% and soil structure is poorly developed due to the short growing season, and it is vulnerable for erosion. Continuous barley mono crop system will cause soil quality deterioration and lack of rotational crop and weed control have prevented adoption of no tillage practice in the area. No tillage practice in the region shows that it reduces soil erosion by wind or water, and improves soil quality (Sharrat et al. 2006a, 2006b, Zhang et al. 2007). However, lack of no rotational crop often makes weed control difficult in no tillage field. Five chemical fallows were used in a 23 year no tillage experiment in the Delta Junction area of Alaska (Zhang, unpublished results). Therefore, a broad leaf rotational crop like canola is needed in the area in order to adopt no tillage practice to conserve soil from erosion and sustain small grain production in the region.

Several polish canola (*Brassica rapa* L.) varieties have been tested as rotational crops in the past but were not successful due to late maturity and high green seed content (Table 1). With introduction of new canola varieties and development of harvesting technologies, canola might serve as a potential rotational crop in the Alaska. The objective of this presentation is to determine a suitable canola variety and harvesting technologies to make the canola as a viable crop in interior Alaska.

Table 1. Canola test results prior to 2007 in the Delta Junction area of Alaska.

Variety	Sources (breeder)	Started year	No. of years tested	Average yield	Average date to maturity	Green seed (%)
Colt	Sweden	1994	7	1264	Aug. 18	9
Eldorado	Alberta, Canada	1993	5	730	Aug. 18	2
Goldrush	Sweden	1996	2	1319	Aug. 27	3
Horizon	Sweden	1994	7	1419	Aug. 17	6
Hysin110	Manitoba, Canada	2006	1	1348	Aug. 15	2
Maverick	Sweden	1996	4	1574	Aug. 10	4
Reward	Manitoba, Canada	1993	11	1245	Aug. 16	8
Sunshine	Alberta, Canada	1994	7	1818	Aug. 18	7

2. Materials and Methods

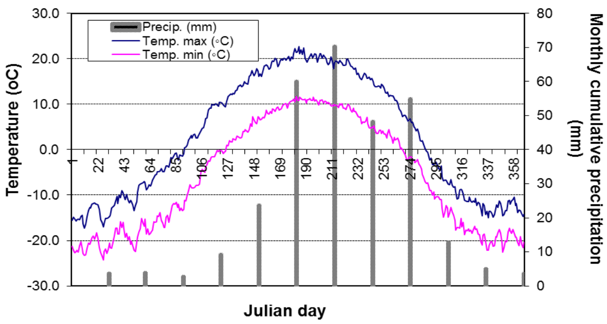

Figure 1. Yearly average (1980-2009) of air temperature and precipitation in the Delta Junction area of Alaska.

The experiment was conducted in the research farms of Agriculture and Forestry Experimental Station of the University of Alaska Fairbanks in Delta Junction area and in Fairbanks from 2007 to 2009. The area has an annual precipitation of 300 mm and mean temperature of -3°C. The 29-year mean precipitation and temperature from May to September were summarized in Figure 1. Soil in the Delta Junction area is Volkmar silt loam (Aquic Cryochept, US Taxonomy, USDA NRCS) and in the Fairbanks area is Tanana silt loam (Typic Aquiturbel, USDA NRCS). Four Polish type canola varieties were used in the experiment, 'Reward', 'Hysin 110', 'Maverick', and 'Sunbeam' with a same seeding rate of 13 kg seeds/ha. Sunbeam was a new Polish canola variety developed in Manitoba Canada, which we collected seeds in 2008 and tested it in the field experiment in 2009. We had a limited seeds for Sweden cultivar 'Marerick', therefore, it was only tested in 2007. There were three harvesting treatments: direct combining (as a control), desiccating, and pushing (to stop growth). The experiments were arranged in a randomized complete block design with four replicates. For direct combine treatment, plots were harvested with a plot combine in late August or early September when canola was ripe, depending on weather conditions. The desiccate treatment was implemented by spraying glyphosate (1.5%) on Aug. 13, 2007 and Aug. 12, 2008 for both Delta Junction and Fairbanks, and Aug. 10 and Aug. 11, 2009 for Delta Junction and Fairbanks, respectively. The plots were then harvested using a plot combine at the same time as the direct combine treatment. For pushing treatment, canola was pushed around Aug. 15 for all three years by a steel tool bar mounted on the three point hitch of a tractor. The tool bar was set to a height of about 13 cm above ground. The tractor was then backed over the plots to push or crimp the stem for stopping growth. Those plots were also harvested using a plot combine at the same time as the direct combine treatment in late August or early September. The seeds harvested from each plot were dried in an oven at 60°C and weighed. The content of green seeds in each treatment was determined by placing 100 seeds in a plastic panel which has 100, 0.32 cm depression drilled into surface to catch one canola seed in each depression. A strip of clear strapping tape was then placed on a sheet of white paper and crushed with a hard plastic roller and the number of green seeds were counted afterward. To test viable seeds from different pre-harvesting treatments, four replicated 100 seeds were placed in moist paper tower, and placed in an aluminum foil pan with a cover. The germinated seeds were counted in 15 days.

Twenty nine year weather data at the Delta Junction area (1980 - 2009) were obtained from National Climate Data Center (https://www.ncdc.noaa.gov/), and were averaged for precipitation and minimum and maximum temperature during the growing season (Fig. 1). We only obtained the weather data in the Delta Junction area due to the proximity of the two sites, and Delta Junction area is the major small grain production area in Alaska. Growing degree day was calculated using 0°C as a base.

All data were statistically analyzed with ANOVA for a split-plot design (variety as main, and pre-harvesting treatment as sub plot) and mean comparison among treatments variety and pre-harvesting treatments. The software for the statistical analysis was Statistix 11 by Analytical Software (Tallahassee, FL, USA).

3. Results and Discussion

Geographically, Delta Junction and Fairbanks areas are located in subarctic regions with annual temperature below zero Celsius. Discontinuous permafrost exists in the both areas. Planting time usually occurs in early May, and harvesting in late August (Fig. 1). The small grain crop that is predominantly grown in the area is barley. Locally developed short growing season hard red spring wheat (*Triticum aestivum* cv. 'Ingal') can reach maturity in the area. But due to seed shattering issue at maturity for this cultivar, it has not been widely grown in the area. Both areas have large acreages suitable for agriculture, which can be a potential area for small grain production in USA (NASS, 2012). Currently, Delta Junction is the major small grain production area in Alaska. The success of a rotational crop in the area is significant for sustainable agricultural production.

Our results showed that direct combining resulted in apparent higher yield as compared to the other two harvesting technologies in Delta Junction area (Table 2). The pushing treatment had the lowest yield in all three years and varieties due to shattering of Polish canola seed pods caused by pushing. In contrast, at the Fairbanks site, the desiccate treatment yielded higher for all three cultivars in 2007 (Table 3). Seed for cultivar 'Maverick' was available in 2007 but not available in 2008 and 2009. Seed of 'AC Sunbeam', a newly released Polish canola variety from western Canada, was available in 2009. As shown in Tables 2 and 3, 'Hysin 110' tended to yield more in all three years as compared to 'Reward'. But the variety was phased out after it was purchased by a private seed company. Desiccation treatment consistently showed that in three years it decreased green seeds content of harvested seeds (Table 2, Table 3). 'Maverick', which has been tested in the both sites for four years prior to this experiment (Table 1), showed a decrease in green seed content after use of desiccation treatment.

Similar observation was found for 'Reward', which had been tested for 11 years before this experiment (Table 1). In all tested cultivars, 'Hysin 110' consistently had a lower green seed content (<2%) for both sites. But for other cultivars, green seed content in desiccate treatment in 2008 had more than 2% green seed content (Table 2, Table 3).

Table 2. Yield results of harvesting treatments for all tested canola cultivars from 2007 to 2009 at Delta Junction site.

Variety	Harvesting tech.	Yield (kg/ha)			Green seed content (%)		
		2007	2008	2009	2007	2008	2009
Delta Junction							
Reward	Direct combining	1748 ±408	1515 ±134	928 ±136	4	19	4
	Desiccate	1993 ±286	1468 ±160	826 ±96	1	7	1
	Pushing	1015 ±70	1396 ±187	521 ±126	2	10	2
Hysin 110	Direct combining	2055 ±291	1981 ±89	937 ±135	3	8	5
	Desiccate	1972 ±439	1721 ±63	818 ±194	1	1	1
	Pushing	1256 ±323	1584 ±66	515 ±153	3	3	2
Maverick	Direct combining	1012 ±217	NA	NA	4	NA	NA
	Desiccate	1705 ±331	NA	NA	1	NA	NA
	Pushing	862 ±258	NA	NA	3	NA	NA
Sunbeam	Direct combining	NA	NA	934 ±259	NA	NA	3
	Desiccate	NA	NA	887 ±159	NA	NA	2
	Pushing	NA	NA	471 ±90	NA	NA	2
Average for variety							
Reward		1598 b	1460 b	771	2	2	3 a
Hysin 110		1761 a	1763 a	757	2	2	3 a
Marverick		1204 c	NA	NA	3	NA	NA
Sunbeam		NA	NA	765	NA	NA	2 b
Probability (F test)		0.01	0.01	0.88	0.11	0.71	0.02
Average for harvesting methods							
Direct combining		1617 b	1748 a	933 a	3 a	3 a	4 a
Desiccate		1890 a	1559 b	856 a	1 b	1 b	1 c
Pushing		1056 c	1527 b	503 b	3 a	3 a	2 b
Probability (F test)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 3. Yield results of harvesting treatments for all tested canola cultivars from 2007 to 2009 at Fairbanks site.

Variety	Harvesting tech.	Yield (kg/ha)			Green seed content (%)		
		2007	2008	2009	2007	2008	2009
Delta Junction							
Reward	Direct combining	1225 ±415	1391 ±169	1075 ±317	4	7	5
	Desiccate	1755 ±420	2169 ±108	2206 ±230	1	4	1
	Pushing	1073 ±248	1075 ±486	1026 ±277	5	4	4
Hysin 110	Direct combining	1149 ±551	1909 ±430	813 ±488	4	7	3
	Desiccate	1880 ±207	2656 ±78	2425 ±103	2	2	1
	Pushing	1014 ±630	1378 ±398	1484 ±508	2	6	3
Maverick	Direct combining	1390 ±574	NA	NA	5	NA	NA
	Desiccate	2330 ±289	NA	NA	1	NA	NA
	Pushing	1209 ±461	NA	NA	5	NA	NA
Sunbeam	Direct combining	NA	NA	1166 ±439	NA	NA	2
	Desiccate	NA	NA	2291 ±147	NA	NA	1
	Pushing	NA	NA	1413 ±292	NA	NA	3
Average for variety							
Reward		1351 b	1544 b	1496	3 b	5	3 a
Hysin 110		1347 b	1981 a	1574	4 a	5	2 b
Marverick		1643 a		1623	3 b		
Sunbeam							2 b
Probability (F test)		0.02	<0.01	0.69	0.02	0.63	<0.01
Average for harvesting methods							
Direct combining		1255 b	1650 b	1018 c	4 b	7 a	3 a
Desiccate		1989 a	2413 a	2307 a	1 c	3 b	1 b
Pushing		1099 b	1227 c	1368 b	6 a	5 a	3 a
Probability (F test)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

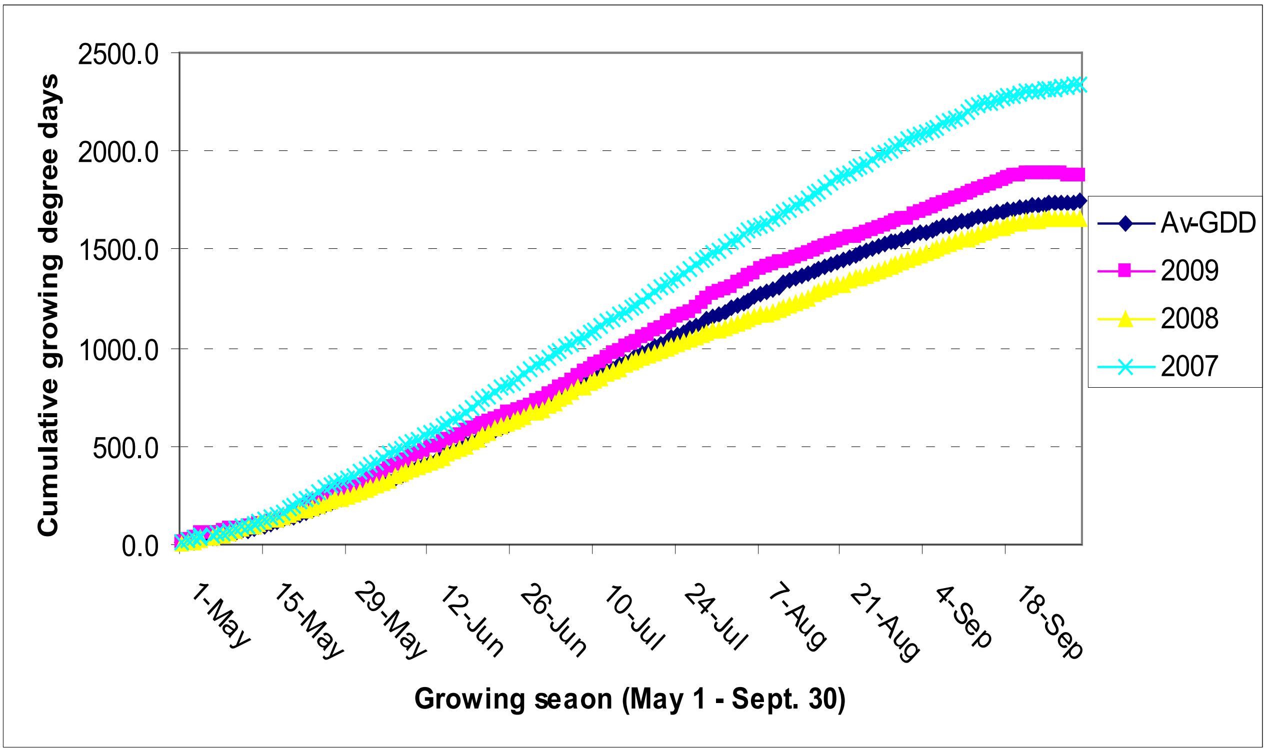

Figure 2. Growing degree days in 2007, 2008 and 2009 collected in test site in Delta Junction area of Alaska.

In all three years, cumulative growing degree days were high in 2007, and low in 2008, with a close to normal year in 2009 compared to the 29 year norm (Fig. 2). In 2007, the growing degree days from May 1 to Sept 30 were 2341. In comparison, the growing degree days for 2008 for the same time period were only 1653. There were 688 growing degree days shorter in 2008 compared to 2007 (Fig. 2). These differences were also reflected in the green seed content in the direct combining and desiccate treatments. For example, the green seed content for 'Reward' at Delta Junction site was 4 in every 100 seeds in 2007 but 19 in 2008 for direct combining. For desiccate treatment, the green seed content for 'Reward' was only 1 in every 100 seeds in 2007, but 7 in 2008 (Table 2).

Green seed content ≤ 2% is an industry standard for No. 1 grade commercial canola oil production estimated by Canadian Grain Commission's Grain Research Laboratory (Unger, 2015), which is equivalent to 25 mg/kg seeds chlorophyll content. By use of glyphosate as a desiccating chemical around Aug. 15 in our study, the growth of canola was prohibited and eventually died. In our experiments, after spraying treatment, there were proximately two weeks prior to harvesting. However, the desiccate treatment in the test areas showed that some polish canola cultivar can reach ≤ 2% green seed content (such as 'Hysin 110'), while the others can't (such as 'Reward') (Tables 2, 3). Our results also showed that in a year with high growing degree days (such as 2007), the desiccating treatment could make ≤ 2% green seeds for 'Reward'. But in a year with low growing degree days such as 2008, 'Reward' still contained high amount of green seeds even after treating with glyphosate. All those data indicated that glyphosate can desiccate canola, but its effectiveness was dependent on growing degree days and types of cultivars in Alaska. Canola cultivars with a lower growing degree day requirement are still a preference when selecting canola cultivars as a rotational crop in Alaska. 'Hysin 110' had consistently ≤ 2% green seeds, indicating that it is a viable cultivar for growing in Alaska. The newly released Polish canola cultivar 'AC Sunbeam' also showed a ≤ 2% green seed content in 2009. In the consequent years since the end of this study, field experiment with the desiccation treatment with AC 'Sunbeam' have also yielded ≤ 2% green (data not shown), showing that it was also a good cultivar for Alaska. Given the fact that 'Hysin 110' was purchased by a private company, and has been phased out in the marked for seed production, AC 'Sunbeam' might be the only choice for Alaska farmers in the future.

Table 4. Viable seed content of harvesting treatments for all tested canola cultivars from 2007 to 2009 for Delta Junction and Fairbanks.

Variety	Harvesting tech.	Germinated seed (%)			Germinated seed (%)		
		Delta Junction			Fairbanks		
		2007	2008	2009	2007	2008	2009
Reward	Direct combining	98 ±1	78 ±3	94 ±2	77 ±2	87 ±3	91 ±2
	Desiccate	95 ±2	70 ±4	95 ±1	88 ±3	86 ±2	96 ±1
	Pushing	93 ±2	91 ±1	89 ±1	78 ±4	80 ±3	95 ±1
Hysin 110	Direct combining	94 ±2	88 ±2	94 ±2	79 ±2	91 ±3	82 ±2
	Desiccate	98 ±1	70 ±4	93 ±1	92 ±5	89 ±2	93 ±1
	Pushing	98 ±1	91 ±1	97 ±<1	90 ±5	94 ±1	92 ±1
Maverick	Direct combining	86 ±2	NA	NA	64 ±3	NA	NA
	Desiccate	91 ±4	NA	NA	89 ±4	NA	NA
	Pushing	93 ±3	NA	NA	75 ±4	NA	NA
Sunbeam	Direct combining	NA	NA	92 ±1	NA	NA	90 ±1
	Desiccate	NA	NA	97 ±1	NA	NA	91 ±2
	Pushing	NA	NA	96 ±1	NA	NA	83 ±1
Average for variety							
Reward		95 a	78	93 b	81 b	84 b	94 a
Hysin 110		97 a	83	95 a	87 a	91 a	89 b
Marverick		90 b	NA	NA	76 b		88 b
Sunbeam		NA	NA	95 a			
Probability (F test)		<0.01	0.06	0.01	<0.01	0.01	<0.01
Average for harvesting methods							
Direct combining		92 b	83 b	93 b	73 c	89	88 c
Desiccate		95 a	67 c	95 a	89 a	87	93 a
Pushing		95 a	91 a	94 ab	81 b	87	90 b
Probability (F test)		<0.01	<0.01	0.01	<0.01	0.38	<0.01

With a use of glyphosate in late growing stage, there was a concern on the residual glyphosate in canola seeds. Viability test for seeds from desiccating treatment showed that seeds from the desiccation treatment had germination more than 85% indicating that seeds were viable and no residual glyphosate might be contained in seeds (Table 4).

With use of new Polish canola varieties in combination with the desiccating pre-harvest technology, canola now has proven to be a good candidate for a rotational crop for interior Alaska. Because of low green seed content, oil from canola seeds grown in interior Alaska can be either used for human consumption or as feedstock for biodiesel. Our experience showed that the direct combine harvesting of immature canola was rather difficult, and additional handling was required after combining.

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