Seed and Oil Yield of Canola in Richmond BC

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Abstract.

Canola was developed in Canada 50 years ago and made up of growers, seed developers, processes and exporters. Canola may generate ~ $30 billion in economic activity each year. [4]. Canola oil is refined as a cooking oil, margarines and can be used in biofuel production. Canola meal is a palatable protein for livestock and human consumption. In our experiment, we used a Randomized Complete Block Design since all of our treatments were randomized within each block. We had the three treatments, 3 planting dates and four replicates in 12 plots, measuring 3 x 3 m (9m2). The only factor that we were concentrating on was the planting dates of canola. We were under the impression that they would be significant effects of planting time on canola seed or oil yield. We had a pretty long field and we assumed that there would be variability in soil, minerals and nutrients and water regimes between each of the plots. After harvesting, threshing, weighing and oil extraction, we used Jamovi's ANOVA [1&2] to calculate the results every weight of seed to weight of the oil. We were amazed on the outcome of these statistical measures.

Introduction.

The purpose of our experiment is to distinguish whether or not the different planting dates of canola, have an influence on canola seed and oil yield. Canola with its low erucic acid level (< 2%)(High levels of erucic acid in food can impair health) varieties of Brassica napus, B.rapa or B.juncea are bright yellow flowering Brassica bred from rapeseed that produces the world's third-largest source of vegetable oil and second largest source of protein meal. Canola crops help reduce soil erosion, increase carbon sequestering and moisture retention during dry times. Richmond, British Columbia has a near-perfect climate for growing canola, with longer day length and cooler nights, so that we get increased oil quality and quantity. The canola seed is made up of ~ 45% oil and the rest in livestock protein feed (as well as human consumption). It is rich in levels of methionine, lysine, arginine and essential minerals. Canola is grown by 43,000 Canadian farmers who produce about 20 million tonnes of canola annually. We have mapped out a long experimental field and are uncertain on environmental effects that would occur between and within each block. We used a Randomized Complete Block Design because all of my treatments were randomized within each block and it can be used to control variation in our experiment by, for example, accounting for soil aggregate or water regimes. The results of the experiment were not expected, having visually seen and tended to each plot and seemed to understand the output of the yield each plot would produce.

Methods.

Plot management.

We had to prepare the plot with a rototiller and then I had to manually weed with tools such as a 3-tooth cultivator, stirrup hoe, collinear hoe and a rake. The plots needed a relatively smooth surface on which the Jang seeder would be able to seed the canola. In late March, I broadcast a cover crop of buckwheat. There was no compost application on any plot there was clean cultivation immediately before seeding. (Clean cultivation: In this method of soil management the space between plants is kept clean by tillage and removal of weeds. Advantages. Removes competition of weeds for light, water and nutrients from crop and avoidance of alternate host for pests and diseases).

For the first planting on April 1, 2021, 10 days later there was no evidence of emergence. We were under the impression that there was enough moisture in the soil to facilitate this growth and I also realized that weeds and the buckwheat cover crop were emerging and overrunning the plots. The surface of the soil had not been to my standard and therefore I had to prepare the plots thoroughly for the second time.

Figure 1.

Experimental field layout in the right-hand side marked as blue from North to South.

Planting.

We used a Target Plant Density plan from Canola Council of Canada.

1. Target Plant Density from Canola Council of Canada: 64 plants/m2
2. Jang seeder in-row spacing: 1.5” = 3.8 cm
3. Rows per plot: 10
4. Row spacing = 3 m / 10 rows = 0.3 m = 30 cm
5. Seeds per 3 m row = 300 cm/3.8 cm = 79 seeds per row
6. Seeds per plot = 79 seeds/row x 10 rows = 790 seeds
7. Seeding density = 790 seeds / 9 m2= 88 seeds/m2

Table 1 Planting regime for canola.

Season	Seed(field)
Early	4-20-2021
Mid	5-4-2021
Late	5-18-2021

Figure 2. Jang seeder.

Irrigation.

I introduced five lines of drip tape running through full length of study site and physically monitored the soils moisture and irritated every 2 to 3 days. Summer of 2021 was extremely hot and crop was monitored on a daily basis. The surface area of canola of leaves is quite large, so monitoring the rate of transpiration and respiration was important.

Weed management.

There was weekly weed management on each successively planted plot. Time constraints during the week resulted in me weeding over the weekend for the next month and a half. Although one thinks that the canopy of the crop would eventually cover the weeds photosynthetic abilities, this was not the case. I will never underestimate the power of a cover crop such as buckwheat. It was resilient and some of the plants were still on par with the canopy of the canola. In order for my crop to have the best opportunity to grow and be plentiful, weeding was an important factor for this goal.

Table 2. Canola harvest.

Season.	Date.	Plots.
Early	07-22-2021	2,9,17,20.
Mid	07-29-2021	4,10,18,23.
Late	08-03-2021	3,11,16,24.

Harvesting.

We harvested a 1x1 meter squared block in the middle of the plot to avoid border affects which the canola may incur greater vigour of plants that border with unsown areas may give an error to the results of this field experiment. Harvesting was done by using a hand sickle and the canola was gently wrapped in tarpaulin to avoid loss of seed. The canola was and stored in a cool dry area to avoid decay due to mould until ready to thresh.

Figure 3. Harvesting canola.

Figure 4. Canola covered.

Figure 5. Canola covered.

The timing of harvesting the canola was subject to the voracious feeding habits of small birds which forced the situation of earlier harvest time for the early canola plantings. This in turn resulted in placing a cover over the remainder of the canola plantings.

Processing.

Releasing the chaff from the seed was labour intensive. Care must be taken not to lose any of the tiny canola seeds. The best method with the tools at hand was by laying down a large tarpaulin on a flat concrete floor and the bushels of canola were wrapped up fairly tightly to prevent any of the tiny seeds escaping this process. I proceeded to stamp with my boots on the enclosed in a tarpaulin, therefore eliminating most of rough chaff. I carefully opened the tarpaulin and physically and thrashed the remaining closed canola pods. Carefully removing the waste stems and empty pods and using a sieve of the appropriate size to separate the majority of the chaff left behind. It was important to keep each plot separate during this whole process. We then placed each plot of seeds into a chaff extraction unit which uses a stream of regulated air to separate the final pieces of chaff from the seed. Regulation of the air was imperative because the canola seed is extremely light as is the chaff that we were trying to extract.



Tarpaulin and physically stamped on. Chaff extraction unit.

Each sample plot of seeds was weighed and marked with the samples' ID by individually first weighing the prospective container, weighing container and seed and then taking the difference to find the true weight of the seed. The samples were dried in an oven at 150°C to reduce moisture in the seed. (Moisture in the seeds would gum-up the oil extractor). In order to ensure that we got the maximum amount of oil from each plot, we used extra seeds (not used in the experiment) from sowing and used them as a primer sample for the first run. This first run was a dry run that has a lower yield compared to the subsequent runs. The extraction machine included a heating element for maximum oil yield. The resulting heat extracted the maximum amount of oil out of the seed. The resulting individual oil samples were then weighed after straining and weight recorded.


Heated Oil Extractor. Oil samples ready for data processing.

Results.

Experiment layout named Block 1, Block 2, Block 3, and Block 4.

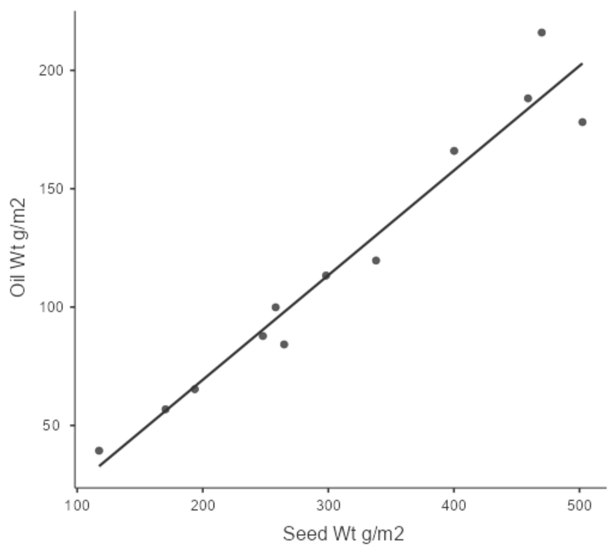
The only hypothesis that I'm testing is that there is a difference in planting dates.

We used a Randomized Complete Block Design because all of my treatments were randomized within each block. We had the three treatments, 3 planting dates and four replicates in 12 plots, measuring 3 x 3 m (9m2). The only factor that I was dealing with was the planting dates of canola. The reason of having the four different plots was because we know there can be variability within this patch of land, such as, variance of soil, environment, nutrition/minerals and water conditions in. Also the variables that we can put in as a control. This is the reason why we decided to use a randomized complete block design, if there were effects from the north side of the field to the south side of the field, we would be able to separate those effects out so that we could just look at the difference that was caused by the planting date. And the blocking was to be able to exclude any other differences that might have been caused by the location in the field. Planting days are shown in **Table 1**. (unfortunately our earlier planting 2 weeks earlier had no emergence and we had to again prepare plots, weed and irrigate and then plant at the stated times.)

Before we could do our analysis of variance using ANOVA **[1],** we had to satisfy underlying assumptions with the data that we were using. The assumptions are looking for a relationship between a continuous variable on the X axis in a continuous variable on the y-axis. We require 2 continuous variables which are seed weight and oil weight. These two variables should be related to each other. In other words the weight of the seed should determine the weight of the oil in each block. Seed weight is on the X axis and oil weight on the y-axis shown in **Graph 1.** Using a scatterplot and linear regression line from Jamovi **[2],** the data lines up into a positive relationship between seed weight and oil weight. Before we use that data for ANOVA we need to ensure that the data is normally distributed or is approximately bell curved. (If it's skewed to the left or the right, then we could not go on with the analysis.)

Estimated Marginal means.

Graph 1. Seed Weight (g/ms) versus Oil weight (g/m2)



Scatterplot indicating Seed Wt. (g/m2) in comparison to oil Wt. (g/m2)

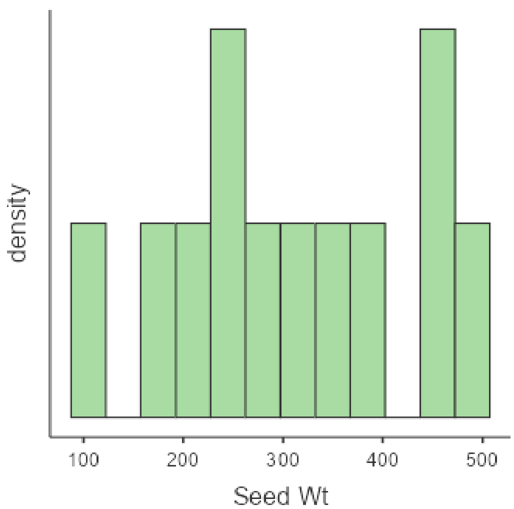
We used Jamovi [1] for the experiment's calculations.

Seed weight on the X axis and oil weight on the y-axis. Using a scatterplot and linear regression line from Jamovi, the data lines up into a positive relationship between seed weight and oil weight.

The next assumption to be met, would be to represent and analyse the data through a histogram (**Graph 2 and 3**) a box plot (**Graphs 3 and 4**) and a Q-Q plot. These are ways to determine whether the data that we collected is normally distributed or not. If there is normal distribution in this experiment you would imagine that the dots on the Q-Q plot would line up. (Shown in **Graph 6**)

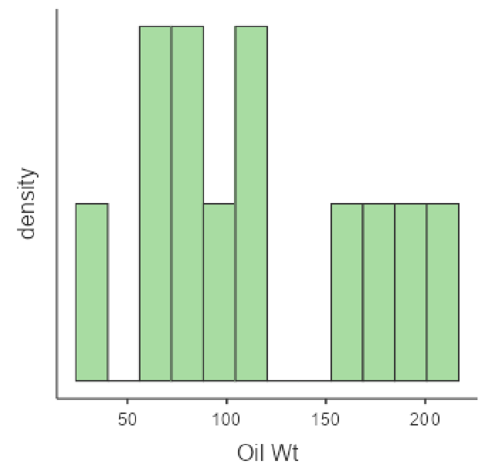
Assumption checks.

Graph 2.



Histogram showing seed weight versus density

Graph 3.



Histogram showing oil weight versus density

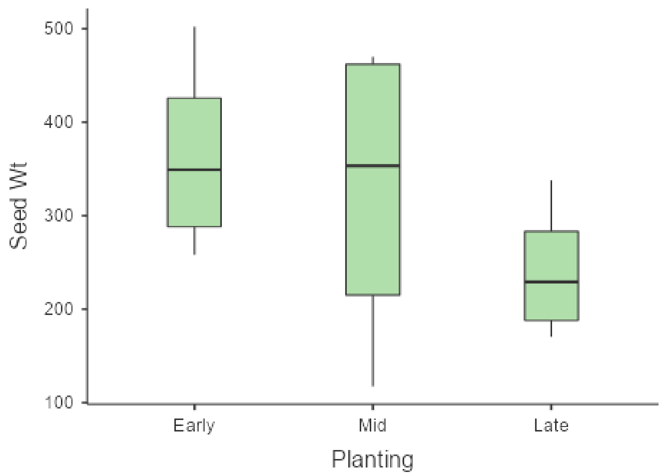
Table 3. Descriptives table.

Descriptives

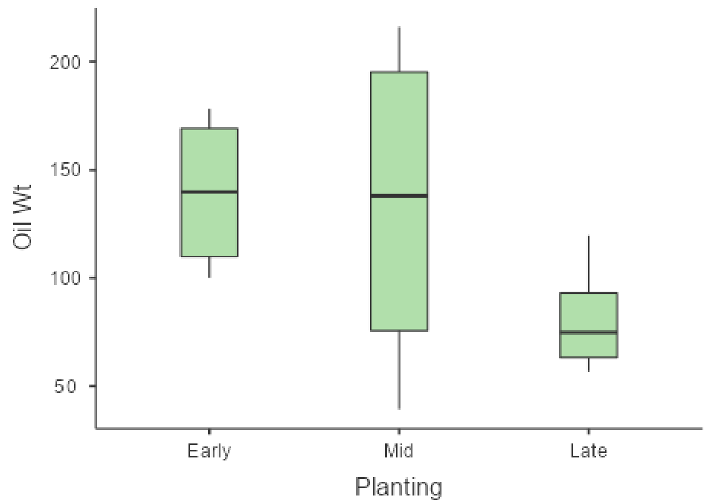
	Seed Wt.	Oil Wt.
N	12	12
Missing	0	0
Mean	310	118
Median	281	107
Standard deviation	125	56.9
Minimum	117	39.3
Maximum	502	216

The means seed will yield was 310 g/m² and the oil seed weight was 118 g/m². The results showed that we had a balanced data set as we expected the median and the mean to be pretty similar. The standard deviation is the variability around that mean.

Graph 4.



Graph 5.



Graph 4 and Graph 5 depicting planting versus seed weight and or weight respectively. In these box plots the median is slightly skewed and although the whiskers should be the same length we figured that this information would be adequate enough to continue our assumptions checks.

Table 4.

Normality tests

	statistic	p
Shapiro-Wilk	**0.933**	**0.414**
Kolmogorov-Smirnov	0.151	0.910
Anderson-Darling	0.384	0.336

We see more variability in the box plot midseason planting then in the others. So with our underlying assumptions, part of it is that we have a normal distribution and we expect the box plot to be balanced, another assumption lies in a test called homogeneity of variances **[3]** and, so all of these box plot should be about the same length. This middle box plot is quite big bigger than the other ones, and may be attributed to a number of variations such as soil type, water etc. We were only to assess planting dates of canola.

The Shapiro Wilkes value, tests the hypothesis that the data are normally distributed and the failure to reject the Null hypothesis, the working assumption is a normal distribution, if the Shapiro Wilk value is below .05 then we reject that Null hypothesis of a normal distribution. The result of the Schapiro Wilk value is not below .05 which leads us to believe that there is insufficient evidence to reject the null hypothesis. Our findings were normal enough (since we did not have a lot of data) so that now we could conduct the ANOVA analysis.

Graph 6. Q-Q Plot

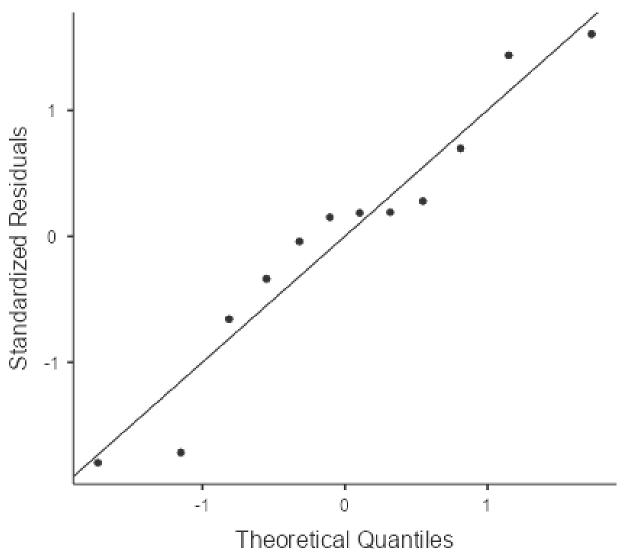


Table 5.

Normality tests

	statistic	p
Shapiro-Wilk	**0.933**	**0.414**
Kolmogorov-Smirnov	0.151	0.910
Anderson-Darling	0.384	0.336

The QQ plot. All of these tests are ways of determining whether the data is normally distributed or not. If you had normal distribution you would imagine the dots on the QQ plot to line up. They line up pretty good for our experiment.

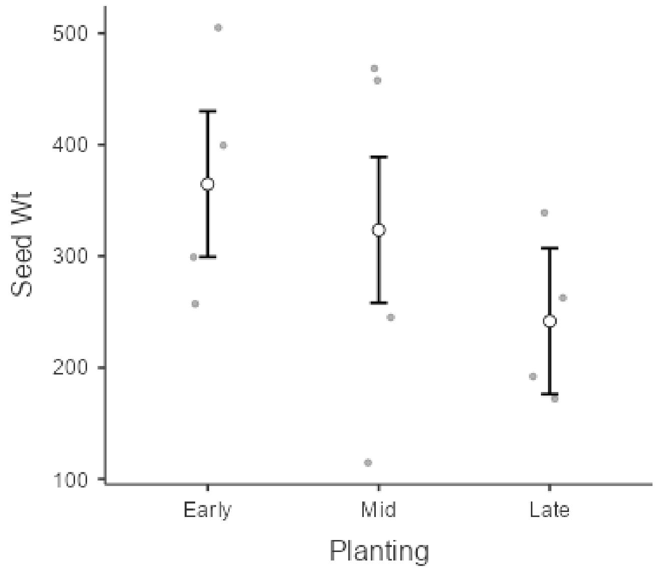
Table 6. Seed Weight (g/ms) versus Oil weight (g/m2)

Descriptives	Seed Wt.	Oil Wt. G/m2
N	12	12
Missing	0	0
Mean	310	118
Median	281	107
Standard deviation	125	56.9
Minimum	117	39.3
Maximum	502	216

This is the analysis of the variation table. ANOVA seed and oil weight (g/m2)

Estimated Marginal means.

Graph 7. Planting date versus seed weight (g/m2)



These are the data points with the mean and standard error bars, which tell us the overall average value for a specific level of some variable. A profile plot of one factor shows whether the estimated marginal means are increasing or decreasing across levels

Table 7. Planting date versus seed weight (g/m2)

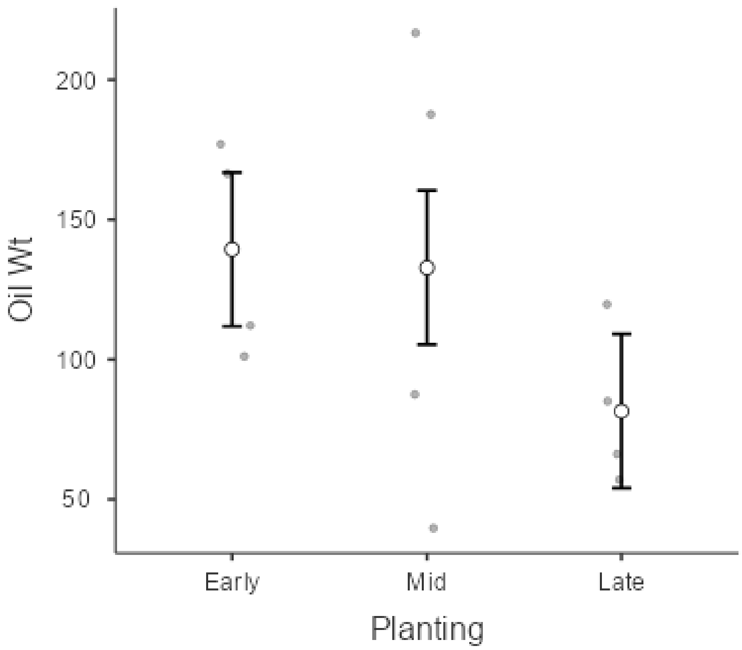
Estimated Marginal Means - Planting

			95% Confidence Interval	
Planting	**Mean**	**SE**	**Lower**	**Upper**
Early	**365**	**65.4**	**204.6**	**524**
Mid	**324**	**65.4**	**163.4**	**484**
Late	**242**	**65.4**	**81.6**	**402**

NB. Notice the **red** values under the Mean heading for the mean planting produced for early, 365 g/m², mid 324 g/m² and late 242 g/m². (**See discussion**).

Estimated Marginal means.

Graph 8. Planting date versus oil weight (g/m2) and



These are the data points with the mean and standard error bars.

Table 8. Planting date versus oil weight (g/m2)

Estimated Marginal Means - Planting

			95% Confidence Interval	
Planting	**Mean**	**SE**	**Lower**	**Upper**
Early	**139.3**	**27.5**	**72.0**	**207**
Mid	**132.8**	**27.5**	**65.5**	**200**
Late	**81.5**	**27.5**	**14.2**	**149**

If two SEM (Standard error of the mean) error bars do overlap, and the sample sizes are equal or nearly equal, then you know that the P value is greater than 0.05, so the difference is not statistically significant.

Table 9.

ANOVA - Oil Wt.

	Sum of Squares	df	Mean Square	F	p
Block	**9356**	**3**	**3119**	**1.03**	**0.444**
Planting	**8026**	**2**	**4013**	**1.32**	**0.334**
Residuals	**18172**	**6**	**3029**		

Table 10 and.

ANOVA - Seed Wt.

	Sum of Squares	df	Mean Square	F	p
Overall model	**69806**	**5**	**13961**	**0.815**	**0.580**
Planting	**31358**	**2**	**15679**	**0.915**	**0.450**
Block	**38448**	**3**	**12816**	**0.748**	**0.562**
Residuals	**102758**	**6**	**17126**		

The working assumption is a normal distribution if the P-value is below .05 then we reject the Null hypothesis. However, the statistical **Tables 9 and 10** from ANOVA indicate the P value is above 0.5 and therefore there is insufficient statistical evidence that we fail to reject the null hypothesis and that there will not be a difference in planting dates for our canola crop.

Discussion.

This is the first time we have grown canola in Richmond BC and work were not too certain of the outcome other than experiences of the prairie farmers in Canada. Canola is a cool climate crop so we were not too sure how the spring and summer would affect emergence and growth. We did have an extremely hot summer and I thought that the crop would not survive. Even through the trials and tribulations of the labour, time and worry, the experiment went well. We had a giddy start when we tried to plant on April 1 and there was no emergence by April 8 and I had to re-address the weeds and soil surface of each plot to accommodate a smooth ride for the Jang seeder. (Weeding, in my opinion, is one of the most important things in agriculture so that you do not have to do it too much in the future. I have learnt to analyse an experiment before I walk into it because I was not looking far ahead about conditions of irrigation, weeding, bird pilfering and environmental threats. Unfortunately there was a lot more work to be done on the plots in preparation for seeding which was postponed told April 20. The irrigation system had not been set up per se but there were water hoses that could reach the plots. My dilemma was to come back on Sunday and re-water the plots. I would rather plant on Tuesday, which gives me enough time to organize the irrigation system. (At the moment, it would be linking up three water hoses until the drip irrigation can be set up.) The soils aggregate varied from loam, clay and sand mixtures so there would definitely be a difference of water retention of the soil depending on what plot you were in.

As mentioned before weeding was a constant challenge in each plot, especially with our buckwheat cover crop that seemed to re-emerge even though the canola canopy was dense. I will never underestimate buckwheat again although it's great for soil nutrition. My expectation that the minerals and nutrients, soil composition and water conditions would have a varied difference between the plots. Canola is a cool climate crop. We used a Target Plant Density plan from Canola Council of Canada: 64 plants/m2, as a comparison in our planting. Using a Jang seeder in-row spacing: 1.5" = 3.8 cm with 10 rows per plot in row spacing of3 m / 10 rows = 0.3 m = 30 cm. the seeds per 3 m row = 300 cm/3.8 cm = 79 seeds per row. Seeds per plot = 79 seeds/row x 10 rows = 790 seeds. Seeding density = 790 seeds / 9 m2= **88 seeds/m2.** The excess seed planted was to cover a 2 to 5% failure of emergence because the unusually hot summer environment. We (my professor and I) had thought that earlier on in the project we would get the best yields from the earliest plantings and we can see a bit of a trend as the yield is declining and not unexpected but the effect is not significant. I was disappointed not seeing a plant effect but on the other hand there is the importance of flexibility of planting canola in our climate.

Despite all the problems with birds, irrigation, a hot summer, excessive weeds (and the sister project of Styrian pumpkin) involved in labour all the challenges encountered my yield is twice what is expected from a Prairie farmer. The assumption that there would be effects due to staggered planting was physically and statistically incorrect. We fail to rejected the Null Hypothesis that there is no difference of the seed and oil weight between the 3 planting dates on each of their relative blocks

For the mean planting produced for early, **365** g/m², mid **324** g/m² and late **242** g/m²

365 g per meter squared represents 3.65 tons per hectare. This is a really good canola yield. A Prairie farmer would be happy with 1 ½ times this value so I have more than doubled the productivity when growing canola in Richmond on a small scale basis. The lowest yield is even higher than the typical Prairie farmer. At 2.42 tonnes per square hectare.

Do not forget that our experiment was coddled in comparison to farmers on the Prairie that do not irrigate their crop, but rely on water from the first meltdown of ice and the earliest event when they get to work the soil for planting. They rely on this water emergence and growth of the canola crop.

We have a milder climate and the fact that did we did not have any significant difference between planting dates means that if we want to grow canola, we have a lot of flexibility in comparison to the Prairie farmer. They struggle to get the seeds sown as soon the soil is workable and the crop in because they know that the first frost is going to hit before they get the crop off. For us we do not have to worry about that.

It is disappointing, not to see a planting effect but on the other hand the importance of the flexibility of planting in our climate was well above average yields per square hectare makes the end of this project more satisfying for the labour, time and worry of my crop to be successful. At the end of day, this project and with the results, I feel extremely satisfied about the labour and care tended and about my crop being successful. The end result is that we can plant over a really long period of time and still get a good result in this climate.

Footnotes.

[1]Analysis of variance (ANOVA) is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups) used to analyze the differences among means.

[2]Jamovi a new “3rd generation” statistical spreadsheet. Designed from the ground up to be easy to use, jamovi is a compelling alternative to costly statistical products such as SPSS and SAS.

[3]Homogeneity of variance is an assumption underlying both t tests and F tests (analyses of variance, ANOVAs) in which the population variances (i.e., the distribution, or “spread,” of scores around the mean) of two or more samples are considered equal.

[4] https://www.canolacouncil.org/about-canola/industry/)

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Federal investment supports canola's value and access to global markets

Federal investment supports canola's value and access to global markets | The Canola Council of Canada (kpu.ca)

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Target Plant Density

Target plant density | Canola Calculator (canolacouncil.org)

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