GERMINATION RATES OF SPRING CANOLA (*BRASSICA NAPUS L.*) AND SPRING WHEAT (*TRITICUM AESTIVUM L.*) CULTIVARS IN RESPONSE TO TEMPERATURE

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by

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ABSTRACT

Germination Rates of Spring Canola (*Brassica napus L.*) and Spring Wheat (*Triticum aestivum L.*) Cultivars in Response to Temperature

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Though gaining popularity as an edible oilseed, canola (*Brassica napus* L.) is slow to make its way into the southern United States. Growers in Texas traditionally plant winter canola in the fall and harvest in the spring, similar to winter wheat (*Triticum aestivum* L.) grown in the region; however, this competes with wheat acres as a rotational crop. Mild falls and late freezes in South Texas may allow for a late fall grain harvest of spring canola, if canola seed can withstand hot soil temperatures at planting in late summer. This scenario may allow canola to gain more acreage in the state as part of a double-cropping system with wheat or as a late-planted alternative crop following a failed summer crop, which frequently occurs in Texas. In order to determine spring canola's potential to tolerate hot soil temperatures, seed from four spring canola varieties will be evaluated at seven different temperatures (10^{o}C through 50^{o}C) and the germination rate will be recorded for one week. The goal of this study is to 1) determine the temperature at which spring canola germination declines and 2) determine if spring canola can successfully germinate at soil temperatures common in Texas in late summer.

CHAPTER I

INTRODUCTION

Due to its high heat tolerance and low saturated fat content, canola oil is considered to be one of the most versatile and healthiest oils for human consumption (McDonald, 1990). Its popularity has made canola the third most economically important crop in Canada, after wheat and barley (Eskin and McDonald, 1991). Despite the growing success of canola in Canada and worldwide, farmers in the United States have been slower to incorporate canola into their cropping systems. This hesitancy, which may be due to canola's adaptation to the cooler climates of Canada, is beginning to fade, and canola production is starting to pique the interest of American farmers. Currently, northern states produce much of the United States' canola crop. With around 1.2 million acres of canola planted in 2015, North Dakota produces over 80 percent of the nation's crop (NASS, 2015). These numbers are significantly higher than those in more southern areas. Oklahoma, for example, planted around 150,000 acres in 2015, a mere 8% of North Dakota's production (NASS, 2015).

Canola was developed by researchers at the University of Manitoba in conjunction with Agriculture and Agri-Food Canada in the 1970s when the non-nutritional components of rapeseed were removed and erucic acid content reduced in the plant, which at large doses can be mildly toxic to humans (Gunstone, 2004). This created seed capable of producing high quality, edible oil. Paying homage to its origins, the name "canola" is derived from a combination of "Canada" and "ola" or oil.

The establishment of canola as a rotational crop with wheat could be beneficial to many Texas farmers. Farmers who plant continuous wheat without crop rotation often run into a number of problems, such as increased weed pressure and development of herbicide resistance due to lack of herbicide rotation. Introducing canola into a rotation could help break the cycles of weeds and some diseases, and ultimately improve yields (Young et al, 2014). The contrasting root systems of wheat and canola help create a more favorable soil environment for growing wheat. Because canola has a taproot, it is able to extend its root system deeper into the ground to extract water and nutrients that wheat would not be able to reach. The taproot is also able to create channels in the soil that improve both soil structure and water infiltration (Kirkegaard et al, 1993). The larger biopores created by canola's taproot make it easier for wheat root systems to extend farther and thus have greater access to water and nutrients. In addition, the demand for canola oil in the United States is growing faster than the nation's production of the crop (Raymer, 2002). Therefore, Texas farmers have access to a strong domestic market of an increasingly important commodity.

In the growing regions of the northern United States and into Canada, spring wheat is typically planted in the spring and harvested in late summer. Spring canola has a similar growth cycle in these areas and being a cool-season crop, is better adapted to wet, cool springs. Areas in South Texas have much warmer seasons than these regions of North America and have soil temperatures that range from around 24 to 38° C between March and October. If spring wheat and canola are able to germinate at these warmer soil temperatures, the plants will be able to mature in the fall when temperatures begin to cool and are favorable for flowering and pod fill, thus increasing yield potential and making spring canola a suitable option for certain crop rotations.

Objectives

The overall goal is to provide producers of South Texas with alternative cropping system options for late summer planting. Specific objectives of this study are to:

1) Identify the upper temperature limit at which spring canola and spring wheat seeds will successfully germinate.
2) Determine if temperature tolerance differs among existing spring canola and spring wheat varieties adapted for South Texas.
3) Identify a suitable planting window for double-cropped spring canola and spring wheat in South Texas based on temperature tolerance at germination and common soil temperatures in the region throughout the summer.

CHAPTER II

METHODS

This trial was designed in a four-replicate, factorial split plot design. Main plots were assigned by temperature treatment with canola and wheat variety and replication completely randomized within each main plot. Four adapted spring canola cultivars and two spring wheat cultivars were selected based on performance in previous variety trials. The canola cultivars included two Roundup Ready® cultivars, Pioneer 45H29 and Pioneer 45H31, and two Liberty Link® cultivars, Invigor L252 and Invigor 5440. The two spring wheat cultivars included Expresso and SY Goliad.

Germination testing was carried out in 14 cm petri dishes, with 50 seeds from each cultivar placed in a separate dish, each lined with a paper towel. The paper towel was moistened with a solution of deionized water and Vibrance Extreme fungicide (a.i. Sedaxane, Difenoconazole, and Mefenoxam). The fungicide solution was added to the petri dishes daily to maintain saturation and prevent fungal growth.

Utilizing both a Thermo Scientific Heratherm oven for temperatures over 20^{o}C and a Puffer Hubbard CEC23LTP-ABA incubator for temperatures 20^{o}C and below, germination treatments were tested at 10, 20, 30, 35, 40, 45, and 50° C. The number of germinated seeds was recorded daily for one week or until 100% of seeds had germinated. Thermometers were placed in the oven and incubator and checked daily to ensure constant temperature during the germination process. Seed was considered germinated once a visible radicle had emerged from the seed.

Data were analyzed using SAS 9.2 statistical software using the PROC GLIMMIX command to perform an ANOVA. A maximum soil temperature map was developed in ArcMap using recorded soil temperature data from ten South Texas locations and interpolated using major soil classes across the region to account for differences in heat flux based on soil texture.

CHAPTER III

RESULTS

Interactions were significant ($P<0.05$) for Cultivar*Temperature and Cultivar*Day in nearly every instance, therefore individual cultivars were compared over time and temperature treatments. Only canola cultivars Pioneer 45H31 and InVigor 5440 were used to represent the cultivars with the greatest and least tolerance to high temperatures when germinating. In the range of temperatures tested, both high and low temperatures negatively impacted germination rate and overall percent germination. Canola cultivar Pioneer 45H31 had significantly greater germination ($P<0.001$) at 40°C than InVigor 5440, but there was no significant difference above or below these temperatures. Canola cultivar Pioneer 45H31 had the highest temperature threshold, with germination remaining above the acceptable level (80%) at temperatures up to 41.5°C (Figure 1). InVigor 5440 had the lowest threshold at 36.4°C. Germination of all canola varieties reached a maximum (100%) at 30°C. Of the wheat cultivars, SY Goliad had significantly higher germination ($P<0.001$) at 50°C while Expresso had greater germination at 30 and 45°C. SY Goliad fell below 80% germination at 38°C while Expresso remained above acceptable levels up to 41.3°C (Figure 2). Germination of both wheat varieties reached a maximum of 100% at 35°C. A fifth degree polynomial was used to interpolate between temperature treatments and this was used to estimate germination thresholds by calculating the temperature at which the percent germination fell below 80%. 80% germination was considered the acceptable limit when calculating thresholds as certified seed is generally certified with germination above this threshold.

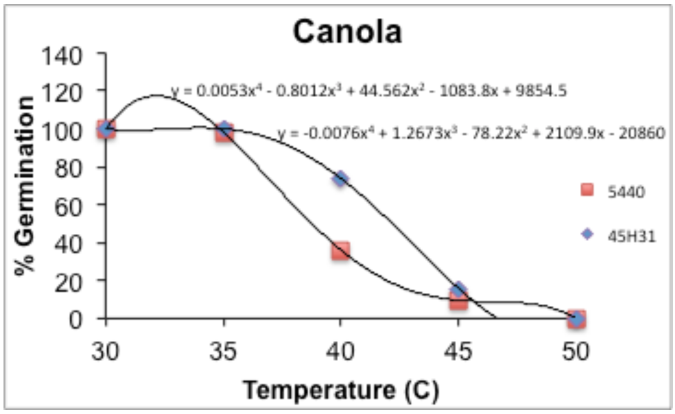

Figure 1 Final percent germination of two canola cultivars, Pioneer 45H31 and InVigor 5440, after seven days over all temperature treatments.

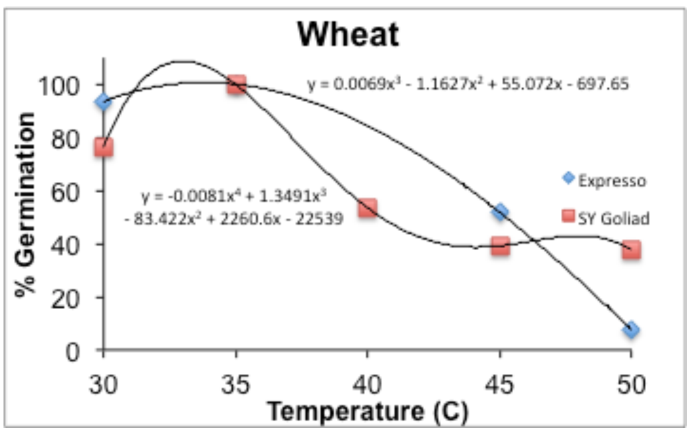

Figure 2 Final percent germination of the two wheat cultivars, SY Goliad and Expresso, after seven days over all temperature treatments.

On average, canola germinated faster than the wheat at temperatures 40°C and cooler, with canola germination close to its maximum after three days while the percent germination for wheat continued to increase through the end of the week (Figures 3 and 4). Wheat had greater final germination than canola above 40°C; however, final germination (<51%) was still well below acceptable levels (<80%) at this temperature range.

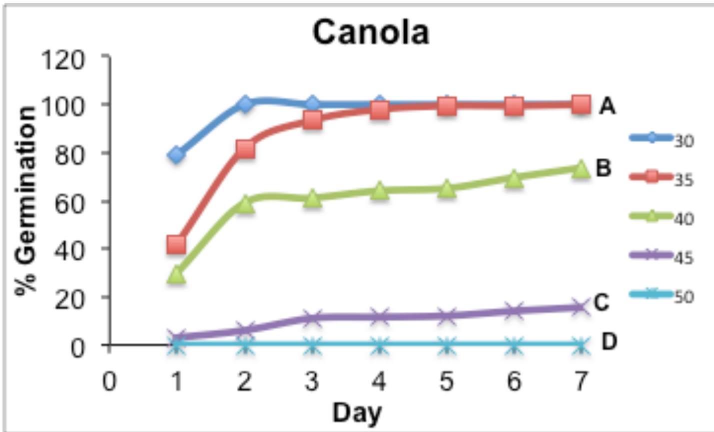

Figure 3 Percent germination of canola cultivar Pioneer 45H31 over time at different temperatures.

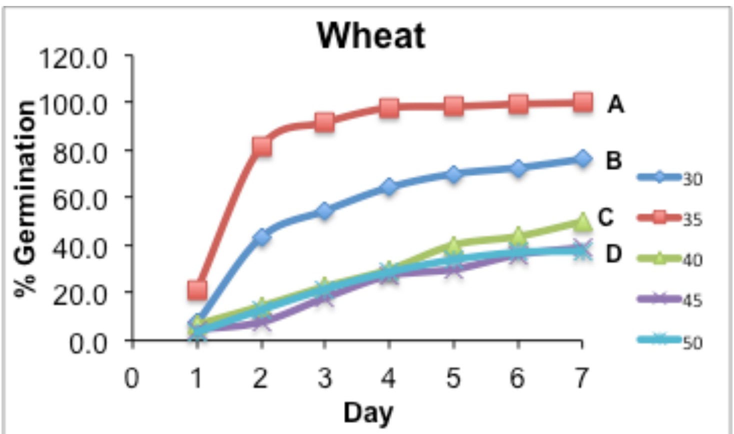

Figure 4 Percent germination of wheat cultivar SY Goliad over time at different temperatures.

CHAPTER IV

CONCLUSIONS

Based on recorded historical soil temperature data, the majority of South Texas soils never exceeded the threshold at which canola and wheat seed fell below 80% germination at the planting depth of 2.5 cm. The small area south of the yellow line seen in Figure 5 is the only area in which soil temperatures may exceed the 36.4°C threshold at certain times of the year. Locations below the yellow line should wait until after September 11 to plant in order to reduce the risk of stand loss due to poor germination.

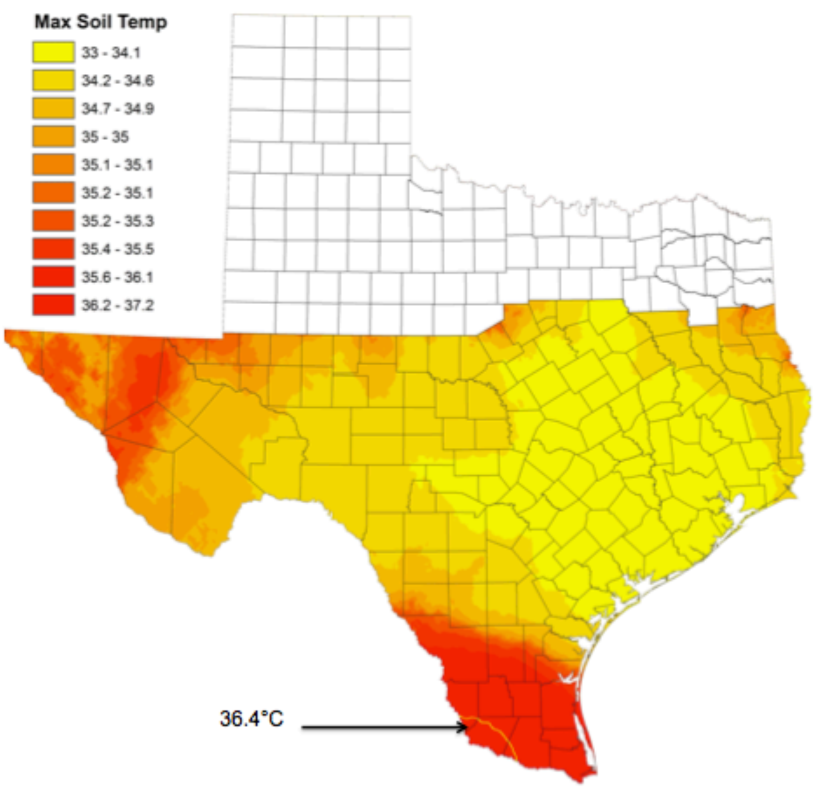

Figure 5 Maximum soil temperatures for South Texas. Areas south of the yellow line may exceed the temperature threshold at certain times of the year.

REFERENCES

Eskin, N. M., & McDonald, B. E. (1991). Canola oil. *Nutrition Bulletin*, *16*(3), 138-146.

Gunstone, F. D. (Ed.). (2004). *Rapeseed and canola oil: production, processing, properties and uses*. CRC Press.

Kirkegaard, J. A., Angus, J. F., Gardner, P. A., & Cresswell, H. P. (1993). Benefits of brassica break crops in the Southeast wheatbelt. *Proc. 7th Aust. Agron. Cons. Adelaide*, 19-24.

McDonald, B. E. (1990). *Canola oil: nutritional properties*. Canola Council of Canada.

National Agricultural Statistics Service (2015). *Crop Production*. Retrieved from usda.mannlib.cornell.edu/usda/nass/CropProd/2010s/2015/CropProd-10-09-2015.pdf

Nykiforuk, C. L., & Johnson-Flanagan, A. M. (1994). Germination and early seedling development under low temperature in canola. *Crop science, 34*(4), 1047-1054.

Perkons, U., Kautz, T., Uteau, D., Peth, S., Geier, V., Thomas, K., & Kopke, U. (n.d). Root-length densities of various annual crops following crops with contrasting root systems. *Soil & Tillage Research*, *137*50-57.

Raymer, P. L. (2002). Canola: an emerging oilseed crop. *Trends in new crops and new uses*, *1*, 122-126.

Willenborg, C. J., Gulden, R. H., Johnson, E. N., & Shirtliffe, S. J. (2004). Germination characteristics of polymer-coated Canola (L.) seeds subjected to moisture stress at different temperatures. *Agronomy Journal, 96*(3), 786-791.

Young, F. L., Whaley, D. K., Pan, W. L., Roe, R. D., & Alldredge, J. R. (2014). Introducing Winter Canola to the Winter Wheat-Fallow Region of the Pacific Northwest. *Crop Management, 13*(1). doi:10.2134/cm-2013-0023-rs