2017 Annual Report for the Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Correlation between NDVI and canola yield: Usefulness of imagery tools to producers

Project Number: 20160382

Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location: AAFC Scott Research Farm, R.M. #380, NE 17-39-21 W3

Project start and end dates: May 2017 –February 2018

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Objectives and Rationale

Project Objective

To demonstrate to producers the optimal timing at which NDVI readings should be taken in canola (*Brassica napus* L.) to maximize the correlation with yield.

Project Rationale

Measurements of early crop vigor have been reported using various methods: biomass, vegetation indices (VI), visual observations, digital image analysis (Regan et al., 1992; Adamsen et al., 1999; Tesfamariam et al., 2010). Labour intensive techniques to measure plant vigour can be replaced with newer remote sensing methods like VI. VI can be used to determine total biomass, leaf area, vigour of plants, growth dynamics (Major et al. 2001; Broge and Mortensen 2002; Xue and Su 2017). Normalized difference vegetation index (NDVI) was first proposed by Rouse et al. (1974) and is the most widely used VI, as it used to monitor and assess canopy characteristics including biomass accumulation, stress and plant vigour (Moges et al. 2004; Freeman et al. 2007; Xue and Su 2017).

NDVI can be measured quickly and with relatively inexpensive equipment like the GreenSeeker® (N Tech Industries Inc., Ukiah, CA, USA). The GreenSeeker is a ground active optical sensor that can provide fast and accurate field measurements.

There is a recent increased interest in the use of remote sensing technology for non-destructive measurements of crop biomass and ground coverage that can be used as a decision-making tool. NDVI, along with biomass accumulation, has been used to calibrate the FAO AquaCrop model for predicting yield in canola (Zeleke et al., 2011). Others studies have reported strong correlations between NDVI and grain yield in different crops (Ma et al. 2001; Raun et al. 2002; Teal et al. 2006)

Currently, producers are keen on utilizing modern technologies in order to make informed economic decisions on their farms, and technology such as the GreenSeeker® can be readily accessible to producers. NDVI values can change depending on the plant developmental stage and canopy closure. Therefore, it is important to establish the optimum stage to measure NDVI for accurate yield predictions. The objective of this demonstration is to show producers around NW SK the optimal timing at which NDVI readings should be taken in canola (*Brassica napus* L.) where a strong correlation with grain yield exists.

Methodology and Results

Methodology

This demonstration was conducted at the AAFC Scott Research Farm in spring 2017 growing season. A randomized complete block design with four replications was used. There were six treatments (NDVI measurement timings) (Table 1). Fertilizer was applied at recommended rates according to soil test results (see Appendix A for complete agronomic details). Pesticides were also applied as and when they were required. All the plots were straight-combined using a wintersteiger plot combine after desiccation with a registered desiccant at the recommended product rate. The grains were cleaned and corrected to the required moisture of 10%.

Table 1: Demonstration treatment list for the 2017 growing season

Treatment	NDVI measurement timings
1	2-3 leaf stage
2	4-6 leaf stage
3	Bolting stage
4	Before flowering
5	Full flowering (100 % bloom)
6	End of flowering (no visible petals present)

Data Collection

Soil residual nutrients were collected in the spring to form a composite sample, used for background information. In-season normalized difference vegetative index (NDVI) was conducted at five different canola stages using a GreenSeeker optical sensor. Yields were determined from cleaned harvested grain samples and corrected to 10% moisture content. Oil content analysis and green seed was collected as well. Weather data was recorded from the online database of Environment Canada weather station.

Growing Conditions

The 2017 growing season started with great soil moisture in April and May with 30.9 mm and 69 mm of precipitation, respectively. Midseason growing conditions in June and July were very dry with 51% and 68% less precipitation compared to the long-term average. Throughout the growing season, the temperature was very similar to the long-term average. Growing degree days were higher than the long-term average for the months of April to July and lower for the remaining months (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to October in 2016 and 2017 at Scott, SK.

Year	April	May	June	July	August	Sept.	Oct.	Average /Total
				Temperature (°C)				
2016	5.9	12.4	15.8	17.8	16.2	10.9	1.6	11.5
2017	3.0	11.5	15.1	18.3	16.6	11.5	3.8	11.4
Long-term[z]	3.8	10.8	14.8	17.3	16.3	11.2	3.4	11.1
				Precipitation (mm)				
2016	1.9	64.8	20.8	88.1	98.2	22.2	33.1	329.1
2017	30.9	69.0	34.3	22.4	53.0	18.9	20.9	228.5
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	13.0	290.6
				Growing Degree Days				
2016	58.9	224.9	303	398.7	343.8	176.2	12.5	1518.0
2017	16.6	202.7	283.3	399.1	348.4	194.8	33.8	1478.7
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	42.5	1474.9

[z]Long-term average (1985 - 2014)

Statistical Analysis

An analysis of variance (ANOVA) was conducted to determine if there was a correlation between NDVI and yield, NDVI and oil content, and NDVI and green seed.

Results

Normalized Difference Vegetation Index (NDVI)

NDVI as a measurement of plant vigour was conducted at six developmental stages (2-3 leaf, 4-6 leaf, bolting, before flowering, full flowering, and end of flowering). No correlation was detected between NDVI and oil content. Same results were observed between NDVI and green seed.

Grain Yield

The objective of this study was to show to producers the optimum developmental stage for a NDVI measurement for an accurate projected yield. This study shows that the four to six leaf stage was the optimal timing to perform an NDVI measurement. At this stage, a strong positive correlation between NDVI and yield was observed (r >0.9) (Figure 1). This could be due to the active plant growth and canopy closure that occurs at the four to six leaf stage. This concurs with a study by Cowley et al. (2014) in Australia, who found that NDVI values were most correlated with canola yield (r >0.7) if readings were taken after 210–320 growing degree-days (usually the mid-vegetative phase of growth). The mid-vegetative phase of growth would be very close to the four to six leaf stage, supporting our results.

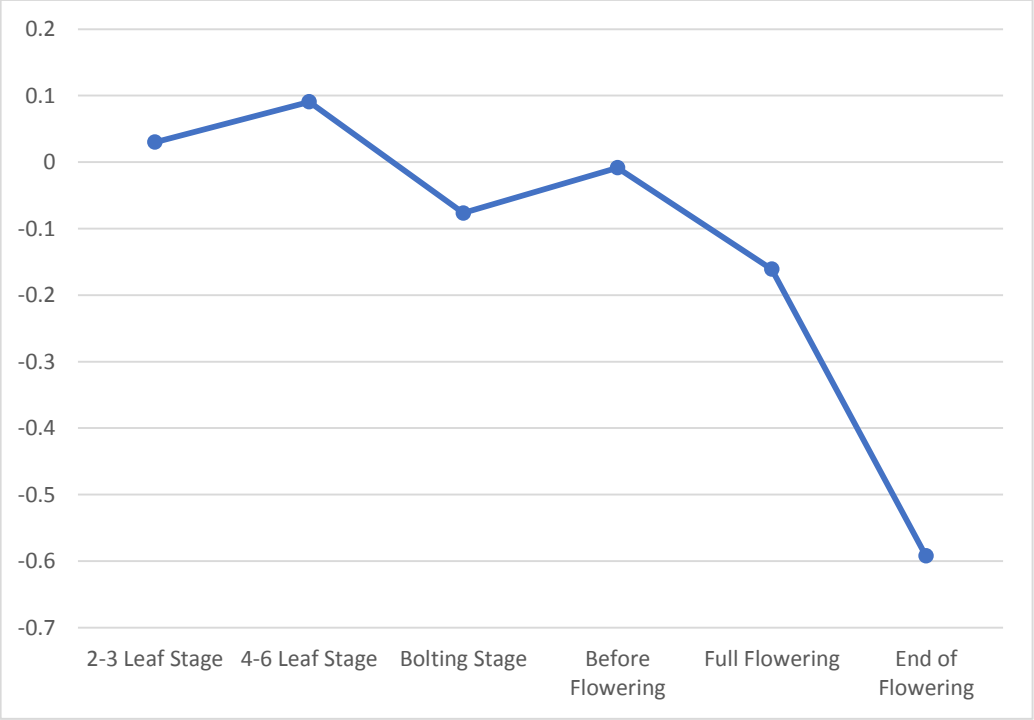

Figure 1. Correlation between NDVI and yield at six different crop stages throughout the growing year

A weak positive correlation was detected at the two to three leaf stage between NDVI and yield. This could be attributed to a smaller plant size at this developmental stage. After bolting and once the plants start transitioning to the reproductive stages the correlation between NDVI and yield becomes negative. This negative correlation is attributed to plant maturity. NDVI values decline as the plant mature and the correlation with yield gets weaker due to the high reflection of the flowers and general senescence of the plants (Basnyat et al. 2005; Martin et al. 2007).

Basnyat et al. (2003) found by comparing the correlation of NDVI with grain yield of three crops, i.e., wheat, canola and field pea in southern Saskatchewan, that there is no single date that consistently had the highest correlations for all crops. The results of the study concluded that the period from 10 to 30 July is the optimal time to relate spectral images to grain yield of spring-seeded crops that reach physiological maturity in August.

Having the knowledge and understanding of when to accurately use NDVI can help producers in numerous ways but should also be used with caution. If an NDVI measurement results in a high yield there are still many factors left throughout the growing season that can affect and/or change that yield prediction, such as pests, disease, rain, etc. Also, yield predictions based on NDVI measurements can assist producers in making difficult decisions throughout the season. For example, if the yield prediction is quite high from the NDVI measurement it may help the producer decide to spray a fungicide or insecticide later in the growing season. In contrast, if the yield prediction is low the producer may decide to save money on the chemicals, especially if the weather conditions have not been favourable.

Conclusions and Recommendations

The results from this trial provided some insights regarding the optimal developmental stage to measure NDVI to accurately predict yield. A strong positive correlation was observed between NDVI measurement at the four to six leaf stage and grain yield. NDVI measurements prior to and after the four to six leaf stage had a weak correlation to yield. NDVI was not correlated with green seed or oil contents at any of the stages assessed.

Based on these results, we concluded that the four to six leaf stage is the most accurate yield indicator in canola. We recommend continuing to monitor fields, as external factors such as insects and diseases, among others, can negatively affect final yield. NDVI should be used as a valuable tool to make management decisions rather than solely a yield predictor.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for funding this project through the ADOPT program. We would like to acknowledge Herb Schell and our summer staff for their technical assistance with project development and implementation. This report will be distributed through WARC's website and included in WARC's annual report.

Appendices

Appendix A – Agronomic information for the demonstration in the 2017 growing season

Abstract

Abstract/Summary

Currently, producers are keen on investing in modern technologies to make informed economic decisions on their farms, and the GreenSeeker® could be part of those investments. To demonstrate to producers the optimal timing at which NDVI readings should be taken in canola (*Brassica napus* L.) to maximize the correlation with yield.

This demonstration was conducted at the AAFC Scott Research Farm in 2017. A randomized complete block design with four replications was used. NDVI measurements were taken at six different growing stages (two to three leaf, four to six leaf, bolting, before flowering, full flowering, and end of flowering). Variables measured were yield, oil content, and green seed percentage.

Correlations were done between NDVI at all stages with the measured variables. Results from this study had a strong positive correlation between an NDVI measurement at the four to six leaf stage and projected grain yield. No correlation with NDVI was detected for oil content or green seed at any stage. This information can provide accurate projected yield estimates to assist producers in making informed agronomic and financial decisions.

Finances

Expenditure Statement

Majority of expenses associated with this project ($4,500) went towards labor required for the establishment of this field trial, including field operations, data collection, extension, sample analyses and contractual services. There was a request for $300 for the Field Day and other tech transfer alternatives such as pamphlets and fact sheets. In addition, $300 was requested for administration costs (see attached expenditure statement for details).

Expenditure information for Correlation between NDVI and canola yield at Scott, SK in 2017 (ADOPT 20160382).				
	Year 1 ($)	Year 2 ($)	Year 3 ($)	Total ($)
Salaries & Benefits				
Students	1,500			1,500
Postdoctoral / Research Associates				
Technical / Professional Assistants	2,000			2,000
Consultant Fees / Contractual Services	1,000			1,000
Rental Costs				
Materials & Supplies				
Project Travel				
Field Work				
Collaborations / consultations				
Other				
Field Day	300			300
Administration	300			300
Miscellaneous				
Total	**5,100**			**5,100**

Appendix A
Agronomic information for 2017 demonstration

Table A.1. Selected agronomic information for the 'Correlation between NDVI and canola yield' trial at Scott, SK.

Seeding Information	**2017**
Seeder	R-Tech Drill, 10-inch row spacing, knife openers
Seeding Date	May 17, 2017
Cultivar and Seeding Rates	Canola (L140P) at 115 seeds/m2
Stubble Type	Wheat
Fertilizer applied	Urea + AS blend: 34-0-0-11 @ 224 lbs/ac mid-row MAP: 11-52-0 @ 29 lbs/ac
Plot Maintenance Information	
Pre-plant herbicide	Glyphosate @ 1L/ac and Bromoxynil @ 0.4L/ac (May 16, 2016)
In-crop herbicide	Liberty @ 0.81L/ ac on June 7, 2017 and 2nd in-crop: Liberty @ 0.61 L/ac on June 21, 2017 3rd in-crop: Liberty @ 1.35 L/ac on June 28, 2017
Fungicide	Priaxor @ 180 mL/ac (July 04, 2017)
Insecticide	Decis @ 6 ml/ac on May 29th
Desiccation	Reglone-Ion @ 0.89L/ac on August 28, 2017
Harvest Date	September 7, 2017

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