Winter Canola Yield and Survival as a Function of Environment, Genetics, and Management

K·STATE Research and Extension

UID: 87643

Yared Assefa, Michael Stamm, and Kraig Roozeboom, Department of Agronomy, Kansas State University, Manhattan, KS

Introduction & Objective

- Stand establishment and survival are two obstacles to production
- Planting date, tillage, and cultivar can be manipulated to improve stand, survival, yield, and oil content
- Two data sets were available to examine management factors affecting canola performance
  - National Winter Canola Variety Trials (NWCVT) from 2003-2012
  - 3-yr planting date (PD) x tillage (T) x genetic (G) study at Manhattan, KS (harvest years 2010, 2011, and 2012)
- The objective of this research was to investigate the impact of environment (location and year), crop management (planting date and tillage), genetics (cultivar), and their interactions on canola stand establishment, survival, yield, and oil and protein content

Methods - NWCVT

- Data from the NWCVT included 26 states, 205 environments, and 282 winter canola genotypes
- Distributions of response variables were studied and plotted using the R statistical package
- Variability in yield, protein, and oil that was explained by genetics, environment, and other factors was analyzed using PROC VARCOMP in SAS
- Yield trends for year, location, and interactions were studied using PROC MIXED in SAS with random genetic and replication factors
- Location interaction justified separating the data into sub-regions
  - Great Plains (CO, KS, MO, NE, NM, OK, TX)
  - Midwest (IL, IN, KY, OH, TN)
  - North (MN, MT, ND, OR, VT, WA, WY)
  - Southeast (AL, AR, GA, MS, NC, NJ, VA)
- Coefficient of variation was calculated to illustrate variability in yield among regions

Results – NWCVT

- Ranges, means, and standard deviations for yield, oil and protein contents of cultivars in the NWCVT are presented in Table 1
- Environment explained 73, 79, and 74% of the variability in yield, oil, and protein, respectively, with the remainder due to genetics or the interaction between genetics and environment (Table 2)
- Year-to-year variations in yield were large, reflecting the overwhelming influence of environment
- By region, the variation in yield was less in the Great Plains (CV = 0.20) < Midwest (0.22) < Southeast (0.25) < North (0.39)
- A positive yield gain ranging from 107 to 138 kg yr^{-1} was detected in the Great Plains and Northern regions, respectively (Figure 1)
- Significant negative correlations exist between yield and late planting for the Great Plains (R=-0.14) and Midwest (R=-0.10)
- 100% stand was measured only 24% of the time when reported
- 85% of sites had >80% survival, and 100% survival was possible 53% of the time with successful establishment

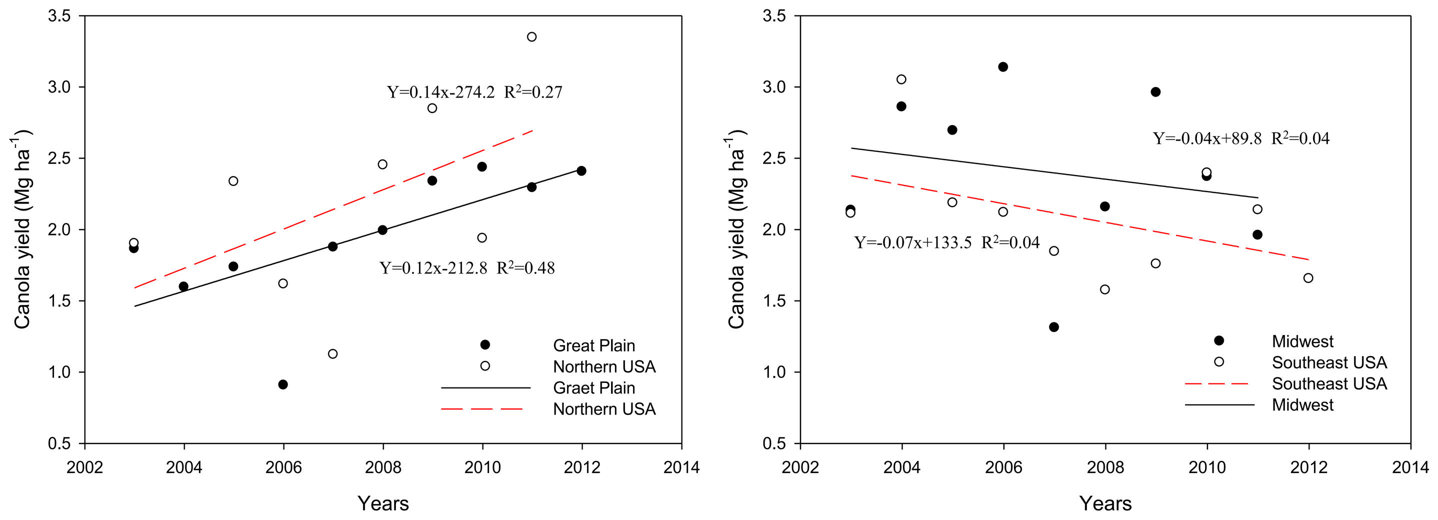
Table 1. Range, mean, and standard deviation (SD) of response variables in the NWCVT, 2003-2012.

	Range	Mean	SD
Yield	0 – 7 Mg ha^{-1}	2.1 Mg ha^{-1}	1.1
Yield (Top 6% removed)	0 – 4 Mg ha^{-1}	2.0 Mg ha^{-1}	0.9
Oil	30 – 47%	39%	3.7
Protein	17 – 33%	25%	2.7

Table 2. Variance ($unit^2$) explained by the main effects of possible source of variation, environment, genetics, and replication in the NWCVT.

Source of variation	Yield	Oil content	Protein content
Environment (E)	0.94	8.98	5.27
Genetics	0.06	0.52	0.60
Replication	0.00	0.00	0.00
Error	0.28	1.90	1.30
Total variance	1.28	11.40	7.17
% of variance explained by E	73	79	74

Figure 1. Winter canola yield trends in the Great Plains, Midwest, Northern, and Southeast Regions of the United States, 2003-2012.



Methods – PD x T x G

- Experimental design was a RCBD with split-split plot treatments. Main plot factor was planting date, the first split was tillage, and the second split was cultivar
- Each year had four planting dates (13-31 Aug; 30 Aug-9 Sep; 13-22 Sep; 20 Sep-3 Oct), two tillage practices (light disk and low-disturbance no tillage), eight cultivars, and four replications
- Cultivars were selected based on yield potential, crown height, winter survival, herbicide tolerance, and hybrid vs. open pollinated
- Planting date, tillage, cultivar, year, and their interactions were treated as fixed effects
- Replication and interactions of replication with whole and split-plot factors were treated as random effects
- Analysis was carried out using PROC MIXED in SAS
- Crown height and winter survival distributions were skewed so the variables were arcsine-transformed before analysis

Results – PD x T x G

- Four-way interaction between factors was not significant (Table 3)
- Three-way interactions of planting date-tillage-year and planting date-genotype-year were significant for yield (Table 3)
- Tillage did not affect yield in any planting date in 2010, but yield decreased significantly when planted 9/18 or later (Table 4)
- Yield did not differ between tillage treatments except for the 9/18 planting date in 2011. Yield increased with later planting.
- No till yielded consistently less than tillage in 2012. Early planting increased yields.
- Cultivars Sitro and Chrome (hybrids) and Griffin (prostrate rosette) tended to have higher yields at early planting (data not shown)
- No-till reduced winter survival only at the earliest planting date in 2010 and the latest planting dates in 2012, but planting date affected winter survival in all years (Table 5)
- Genotype means for survival were separated by year with significant differences observed in 2011 (Table 6)
- Genotype mean differences in crown height were observed in 2010, but not 2011 or 2012
- Griffin had the lowest crown height, and HyCLASS154W (hybrid) and DKW46-15 (Roundup Ready) had the greatest

Table 3. Type 3 test of fixed effects for yield, crown height, and winter survival (WS) at Manhattan, KS.

Source	Yield	Crown Height	WS
Planting date (PD)	***	***	***
Tillage (T)	***	***	***
PD x T	*	**	**
Genotype (G)	***	***	*
PD x G	**	NS	NS
T x G	NS	NS	NS
PD x T x G	NS	NS	NS
Year (Y)	***	***	***
PD x Y	***	***	***
T x Y	***	***	NS
PD x T x Y	**	***	**
G x Y	**	NS	NS
PD x G x Y	**	NS	NS
T x G x Y	NS	NS	NS
PD x T x G x Y	NS	NS	NS

***, **, and * indicate statistical significance at probability levels of 0.001, 0.01, and 0.05, respectively. NS indicates not significant.

Table 4. Mean yield (Mg ha^{-1}) as affected by planting date and tillage in the Manhattan, KS study.

Year	Treatment	8/13[1]	9/1	9/18	10/2
2010	No-till	1.43 a	1.54 a	0.28 b	0.06 c
	Tillage	1.53 a	1.58 a	0.28 b	0.06 c
		8/23	8/30	9/13	9/20
2011	No-till	1.24 d	1.69 c	1.88 bc	2.21 ab
	Tillage	1.47 cd	1.82 c	2.41 a	2.47 a
		8/31	9/9	9/22	10/3
2012	No-till	1.06 c	1.16 bc	0.99 c	0.03 e
	Tillage	1.43 a	1.39 a	1.34 ab	0.78 d

Means followed by the same letter within a year are not statistically significant at P < 0.05.
[1]Planting dates for a given year.

Table 5. Mean winter survival (%) as affected by planting date and tillage in the Manhattan, KS study.

Year	Treatment	8/13[1]	9/1	9/18	10/2
2010	No-till	66 bc	74 b	75 b	47 d
	Tillage	94 a	71 b	75 b	52 cd
		8/23	8/30	9/13	9/20
2011	No-till	64 b	65 b	94 a	89 a
	Tillage	72 b	62 b	93 a	91 a
		8/31	9/9	9/22	10/3
2012	No-till	69 ab	76 a	67 ab	54 b
	Tillage	71 ab	75 a	80 a	67 ab

Means followed by the same letter within a year are not statistically significant at P < 0.05.
[1]Planting dates for a given year.

Table 6. Mean separation for winter survival and crown height in years when these variables differed among cultivars.

Cultivar	Winter Survival 2011 (%)	Crown Height 2010 (cm)
DKW46-15	88.7	4.66
Griffin	79.8	3.52
HyCLASS115W	85.5	4.07
HyCLASS154W	76.0	4.70
Kadore	84.0	3.79
Sitro	69.1	4.39
Virginia	79.8	4.43
Wichita	80.8	3.91
HSD**	12.0	0.86

**Tukey's honest significant difference at P < 0.05.

Conclusions

- Environment (year, location) contributed the greatest percentage of variability in canola yield and oil and protein contents
- Positive yield trends were observed in the Great Plains and Northern US; slightly negative trends in the Midwest and Southeast may be due to a recent decline in number of NWCVT locations
- The NWCVT mean yield of 2.1 Mg ha^{-1} is greater than the 1.6 Mg ha^{-1} national average yield
- Yield tended to improve with tillage, and reductions in yield and winter survival associated with very early or very late planting were greater in no tillage
- Planting date affected yield more than cultivar differences in any given year
- Crown height showed no relationship to winter survival or yield
- No single cultivar distinguished itself as consistently superior for no till or for planting date extremes
- Plant hybrids or varieties with prostrate fall growth at a time that enhances winter survival and maximizes yield potential

Acknowledgments

- This project was funded in part by the USDA-NIFA Supplemental and Alternative Crops program, proposal number 2011-03808.
- This research is published in *Crop Sci.* 54:2303-2313 (2014).