Winter Oilseed Quarterly Research Update #6: Evaluating Phenotypes to Improve Survival in Corn Stover Systems

Katherine Frels[1], Rubi Raymundo[1], Ratan Chopra[2], Maninder K. Walia[1], James. A. Anderson[1], Donald Wyse[1], M. David Marks[2], M. Scott Wells[1]
[1]Department of Agronomy and Plant Genetics, [2]Department of Plant and Microbial Biology, University of Minnesota

Pennycress (*Thlaspi arvense* L., Field pennycress) is a new oilseed-producing cover crop for the Upper Midwest. Although better known as a weedy member of the Brassicaceae family and a close relative of canola, rapid progress has been made to reduce weedy traits in pennycress through domestication [1-3]. Pennycress has many traits required to be a cash cover crop including: extreme winter hardiness, high seed yields, and a short life cycle that allows it to be integrated into the fallow period of existing cropping systems in the Midwest [3-6]. For example, pennycress can be planted into standing corn in late summer or early fall. From fall through spring, pennycress provides a protective living cover, reducing nitrogen loss and soil erosion from farm fields[7].

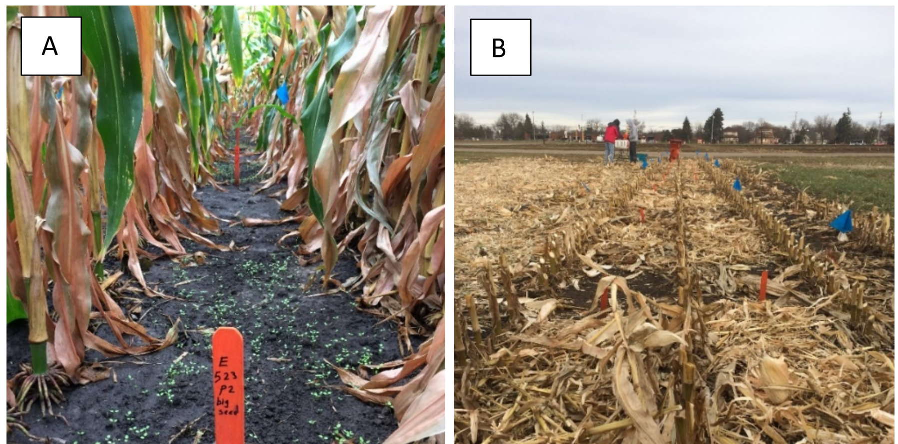

Figure 1. Pennycress-corn stover survival study in St. Paul, 2017. A) Pennycress lines E5-23 one week after planting. B) Plots were covered with stover to simulate combine harvest.

Planting pennycress into grain corn systems remains a challenge in Minnesota and much of the Upper Midwest despite rapid gains in agronomic management and development of improved pennycress breeding lines. Direct seeding pennycress is very successful in cropping systems with minimal residue following harvest, such as small grains, silage or sweet corn, and sugarbeets. Compared to these systems, significant plant residues remain following grain corn harvest. This residue suppresses pennycress growth due to low light levels and also leads to etiolation (excessive stem elongation) which can weaken the pennycress plants, leading to breakage or death over the winter. These weakened pennycress stands show greatly reduced oilseed yields the following spring. The University of Minnesota has been evaluating pennycress interseeding techniques including method and date of planting into standing corn at multiple locations for the past several years. Pennycress oilseed yields ranged from 500 – 800 kg ha^{-1} when interseeded prior to corn harvest compared to residue-free systems where oilseed yields have reached 1500 kg ha^{-1} [8]. Stover removal post-harvest could improve pennycress performance, however, this removal would be too late to

Table 1. Mutant pennycress lines in the study.

Line	Trait
A7-236	Reduced shatter, delayed maturity
A7-129	Reduced shatter
I0218	Reduced shatter
A7-52	Strong stem, reduced lodging
E5-23	Large seed
A7-199	Tall, fasciated seed pods
A7-111	Dwarf, early maturity

alleviate low-light stress on pennycress if farmers use full season corn hybrids. Removing stover would also negatively impact soil organic carbon [9].

In order to investigate other potential solutions to pennycress survival under corn stover, the UMN pennycress research team has developed a study to evaluate the performance of several mutant pennycress lines that exhibit different growth habits and seed phenotypes **(Table 1)**. These lines were collected from a population of pennycress mutants developed for domestication research and have been characterized in field conditions in St. Paul for several years. Small, replicated plots were planted in St. Paul and Rosemount in fall 2017 **(Figure 1a)**. Germination date and percent canopy cover were assessed in the fall prior to corn harvest. In late November, corn stover (excluding ears) was manually removed, chopped, and 0.4 kg of stover (corresponding to the above the ear biomass) was applied per plot **(Figure 1b)**. In May 2018, the pennycress survival rate was quantified using the relative change of canopy cover between fall and spring.

Our preliminary results show the difficulty of establishing and maintaining pennycress as a cover crop in standing corn **(Table 2)**. In both locations, etiolation was observed and could have contributed to the poor survival of the pennycress. Establishment was better in St. Paul, however, overall survival was better in Rosemount. This could be due to waterlogging in the St. Paul plots during the late fall and winter which further weakened plants damaged by low light infiltration. While these results do not show significant improvement in survival under corn residue, the large seeded pennycress line E5-23, showed better survival compared to other lines. The pennycress breeding program is already targeting larger seed size to increase yield and ease seed handling concerns. This research suggests that larger seeds may also lead to more vigorous plants that can better survive in high residue systems. This experiment will be repeated in 2018-2019, and results will inform decisions made in the pennycress breeding program.

Table 2. Fall and spring canopy cover and winter survival for pennycress lines in St. Paul and Rosemount (2017-2018). Green indicates better survival.

Line	St. Paul			Rosemount		
	Canopy cover (%) 11/2/17	Canopy cover (%) 5/1/18	Survival rate (%)	Canopy cover (%) 11/8/17	Canopy cover (%) 5/5/18	Survival rate (%)
E5-23	24.19	1.03	**4.3**	6.5	5.4	**82**
A7-236	6.15	0.06	1	5.1	2.5	49
A7-111	19.82	0.25	1.3	7.6	2.3	29
A7-199	4.58	0.21	4.5	4.5	1	21
A7-129	3.98	0.04	1	4.7	1.2	25
IO218	9.94	0.05	0.5	1.2	2.7	37
A7-52	22.41	0.31	1.4	2.2	5.4	74

References:

[1] Best, K.F. and Mcintyre, G.I. (1975). Canadian Journal of Plant Science 55:279-292. https://doi.org/10.4141/cjps75-039
[2] Dorn, K.M., et al. (2015). DNA Research 22:121-131. https://doi.org/10.1093/dnares/dsu045
[3] Sedbrook, J.C., Phippen, W.B., and Marks, M.D. (2014) Plant Science 227:122-132. https://doi.org/10.1016/j.plantsci.2014.07.008
[4] Chopra, R., et al. (2018) Plant Journal (In Press). https://doi.org/10.1111/tpj.14147
[5] Fan, J.Q., et al. (2013) Biomass & Bioenergy 55:87-100. https://doi.org/10.1016/j.biombioe.2012.12.040
[6] Ott, M.A., Eberle, C.D., Thom, M.D., Archer, D.W., Forcella, F., Gesch, R.W., and Wyse, D.L. Economics and agronomics of dual-cropping pennycress and camelina with soybean in Minnesota. *Agronomy Journal* (2018), in press.
[7] Thom, M et al. (2018) *bioRxiv* http://dx.doi.org/10.1101/254169
[8] Carr, P. M. (1993) Potential of fanweed and other weeds as novel industrial oilseed crops. Pp 384–388. In J. Janick and J. E. Simon, eds. New crops. Wiley, New York, NY.
[9] Walia, M.K., Baer, S. G., and Cook, R.L. (2017) *Journal of Soil and Water Conservation* 72: 405-415. 10.2489/jswc.72.4.405