Field Pennycress: A weed-suppressing winter annual oilseed cover crop

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Introduction:

Throughout the Midwest, much of the conventional agricultural landscape is left barren and without a living cover for large portions of each year. Unprotected soil is especially susceptible to soil erosion and nutrient runoff, leading to grave environmental concerns such as hypoxia, sediment loading in waterways, and the loss of nutrient-rich, essentially irreplaceable topsoil. Cover crop options currently available are difficult to establish and terminate, can increase the risk of drought stress to the main crop, and do not directly contribute to the profitability of the cropping system.

A potential new crop that may mitigate these issues is field pennycress (*Thlaspi arvense* L.), a winter annual species that can be harvested for seed in late May to early June and followed by a full season soybean that can be grown on the same acreage. Integrating field pennycress as a fall-planted cover provides the ecosystem services of a cover crop while also serving as a feedstock for bio-fuel production. This provides farmers with additional income and produces renewable fuel without displacing food production (Fan et al. 2013). Pennycress has also shown a high level of springtime weed suppression, which may reduce the need for tillage and herbicides.

The development of field pennycress as a cover crop at the University of Minnesota is part of the Forever Green Agricultural Initiative, which seeks to establish continuous living cover on the landscape of the Upper Midwest through the development of perennial and winter annual crops.

Figure 1. Pennycress early spring 2011

Figure 2. Pennycress May 5, 2012

What is Pennycress?

Field pennycress (*Thlaspi arvense L.*) is a mostly self-pollinated, winter annual dicot belonging to the mustard (*Brassicaceae*) family. Native to Eurasia, pennycress is adapted to a wide variety of climatic conditions and is common throughout North America. Pennycress is tolerant of marginal lands, requires minimal inputs, and is compatible with existing farm infrastructure (Moser et al.2009). The plant itself is high seed yielding (1120-2240 kg Ha^{-1}) with oil content of 20-36 wt %, resulting in oil yields of up to 1200 L Ha^{-1} which is comparable to other oilseed crops. Pennycress oil is composed of 2.7% palmitic, 13.8% oleic, 20.2% linoleic, 9% eicosenoioc, and 37.8% eruic fatty acids (Carr 1993), making it an excellent choice for use as an industrial biofuel feedstock. Initial screening shows pennycress oil meets all of the United States ASTM D6751 parameters required for biodiesel production (Moser et al. 2009). It has been estimated that pennycress could be grown on 40 million acres of farmland in the corn-soybean rotation, producing over 8 billion gallons of biofuel (Seth 2011). Due to high glucosinolate content, pennycress biomass and seed meal is toxic to animals if fed at high rates. However, studies have shown that seed meal may be used as a biofumigant for limited applications (Vaughn et al. 2005) and that incorporating biomass into fields increases the yield of following soybean crops (Phippen & Phippen 2012).

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Results of Current Research:

Total System Yields

Results from experiments conducted at Rosemount, Waseca, and Lamberton, MN in 2011 and 2012 show that total system yields (pennycress double cropped with soybean) are generally higher than that of soybean alone. Results also show that pennycress does not grow well in combination with other fall covers such as oat and tillage radish.

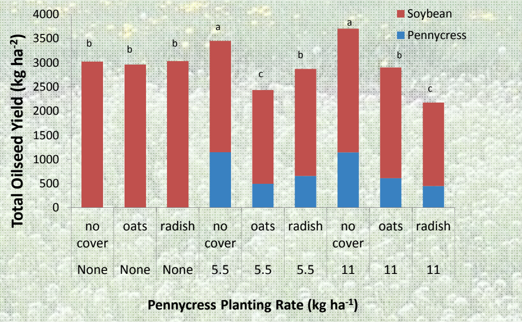

Figure 3. Total oilseed yield at Rosemount, MN in 2012 as affected by planting rate of pennycress and fall cover. Columns with the same letters are not significantly different (LSD =670). Planting rate for oat was 66 kg ha^{-1} and 11 kg ha^{-1} for radish.

Weed Control

Pennycress was very effective in suppressing early spring emerging weeds. As seen in Figure 5, whenever pennycress was planted, there was a 90-100% control of weeds. Our data shows weed suppression is not dependent on pennycress variety, planting date, or planting rate (data not shown).

Figure 4. View under pennycress canopy

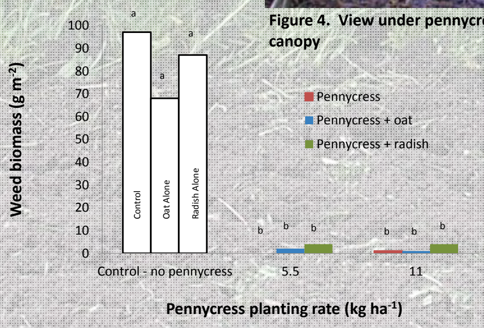

Figure 5. Weed biomass at Rosemount, MN in 2012 as affected by planting rate of pennycress. Columns with the same letters are not significantly different (α =.05).

Continuing Research:

Agronomics

There are several challenges to the adoption of field pennycress as a cover crop in the upper Midwest which are the subject of ongoing research at the University of Minnesota.

Interseeding pennycress into corn and soybean: The optimal planting date (August 1) and harvest date (June 1) for pennycress overlap with those of corn and soybean. We are investigating the feasibility of interseeding pennycress into standing corn and soybean at dates ranging from early summer to early fall.

Relay cropping soybean into pennycress: Relay cropping soybean into pennycress involves no till planting soybean into a field still occupied by pennycress, then harvesting the oilseeds several weeks later over the top of the emerged soybean crop. This maintains early planting of soybeans while allowing for harvest of the oilseed crop. The impact of several durations of relay on soybean yield are being evaluated.

Figure 6. Pennycress interseeded into corn October 2013

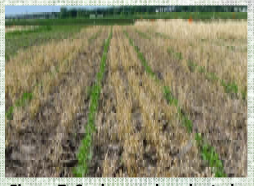

Figure 7. Soybean relay planted into pennycress July 2013

Figure 8. Weed suppression by pennycress (left) compared to no cover (right) June 2013

Breeding

Pennycress is a diploid species and is very closely related to the well-studied, model species *Arabidopsis thaliana*. Recently, researchers at the University of Minnesota finished successfully mapping the pennycress transcriptome, a resource which will aid in the agronomic improvement of pennycress using genomic assisted breeding (Dorn et al. 2013).

In the fall of 2013, a total of 71 accessions collected from Minnesota, the western U.S., Canada, Europe, and South America were planted in two observation field trials in St. Paul, MN. Germplasm is being evaluated for important traits such as vigor, spring vs. winter habit, and percent germination. Preliminary crosses were also made during the summer of 2013 among the 71 accessions, and populations will be advanced throughout the winter and spring in growth chambers.

Breeding and selection efforts will focus on improving seed germination and early maturity. Enhancement of these traits will ensure successful harvest of pennycress prior to springtime soybean planting. Other traits of interest include yield, oil content and quality, height, and canopy cover.

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