Evaluation of Planting Method and Seeding Rates with Field Pennycress (*Thlaspi arvense* L.)

W. B. Phippen, J.V. Gallant, and M. E. Phippen

School of Agriculture, Western Illinois University, Macomb, IL 61455, USA

ABSTRACT

Thlaspi arvense, L. is a common winter annual weed throughout the United States that produces nearly 36% oil content per seed in early spring. Current estimates of wild population seed yields are over 2,240 kg ha^{-1}. Variety selection has begun on this crop to identify high yielding lines, however, to commercialize pennycress, the correct planting method and seeding rate needs to be established to maximize yield and minimize impact on producers.

The objective of this study was to determine the optimum planting method and seeding rate to produce high seed yield, uniform stands for harvesting, and quality oil in spring planted pennycress.

The non-dormant spring pennycress line 'Spring 32' was planted on April 1, 2010 in Macomb, IL following bare ground. Plots were established by drilling on 19cm rows and by broadcasting and at 1.2, 2.2, and 4.9 kg of seed per hectare. Five replicated plots were established for each method and seeding rate combination. On June 18, each plot was harvested and evaluated for seed yield, total seed oil, fatty acid methyl ester content, and several other agronomic traits.

Drilled pennycress plots had a significantly larger number of established plants than the broadcast plots at the same seeding rate. The average seed and oil yield was not significantly different between the drilled and broadcast plots at the three seeding rates. However, seed oil yield per hectare was significantly different between the drilled and broadcast plots but not at the various seeding rates. Plant height decreased with increasing plant populations. More studies will need to be conducted exploring a greater range of seeding rates.

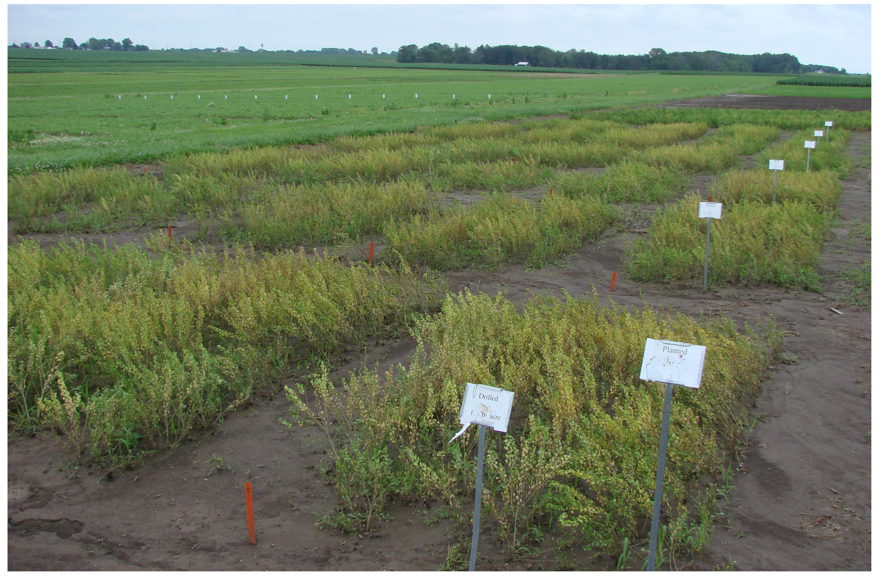

Figure 1. Evaluation plots of planting method and seeding rates with field pennycress planted in Macomb, IL on April 1.

INTRODUCTION

The identification and development of new and alternative crops for fuel and industrial applications is becoming increasingly important in today's economy. Seed oil from the new crop, field pennycress (*Thlaspi arvense* L.) has the potential to be an economically viable, sustainable replacement for many petroleum based products. Pennycress offers a tremendous advantage by supplying this oil in the offseason in the Midwest. Pennycress is a short season winter annual crop that allows a full season soybean to be grown on the same acreage immediately following harvest.

Pennycress is a common plant throughout the Midwest and is a member of the mustard family (Brassicaceae). The small white flowers are predominantly self-pollinated and produce a seed pod containing up to 14 seeds. The small ridged oval seeds have a 1000 seed weight of 0.83 grams. The seed was found to have 36% oil with the major fatty acid being erucic at 38.1% (Moser et al., 2009). Wild populations of pennycress in Illinois can reach a height of 70 cm and produce as much as 2,240 kg of seed per hectare.

Pennycress has been investigated for oil potential (Clopton and Triebold, 1944) and as a potential new source for erucic acid in several industrial applications (Van Dyne et al., 1990). More recent studies have looked at pennycress production as a potential bio-fumigant providing an eco-friendly alternative to methyl bromide (Vaughn et al., 2005; 2006). Pennycress oil meets all the parameters required for biodiesel and demonstrates better cloud point and oxidative stability than soy.

However, for pennycress to be successful in the Midwest, optimum planting guidelines need to be established for plant populations and planting method. Initial studies have indicated that at low planting densities, pennycress has the ability to adapt and produce more lateral branches and increase yield potential, a response similar to cuphea (Gesch et al., 2003). The objective of this study was to evaluate a range of planting densities along with investigating two planting methods to achieve an optimal seed yield and oil quality.

Figure 2. Planter/drill used to established research plots on April 1.

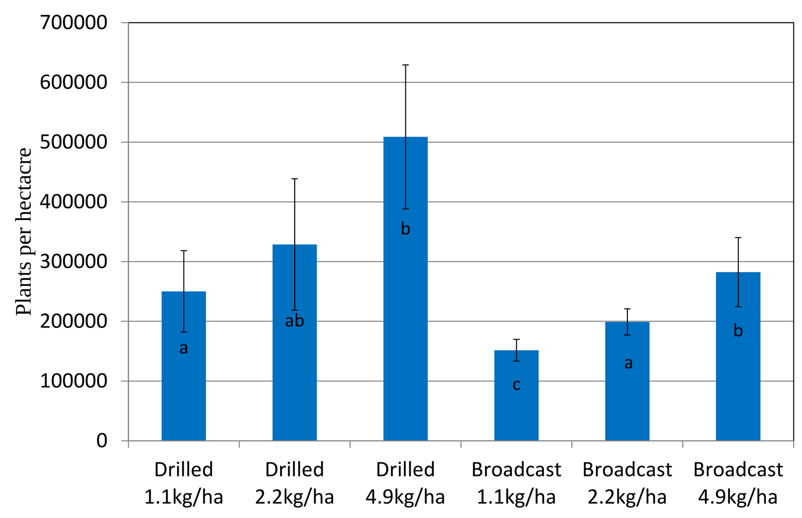

Figure 4. Established plant populations for broadcast and drilled plots at three seeding rates. Different letters in bar graphs indicate significant differences at the P<0.05 level.

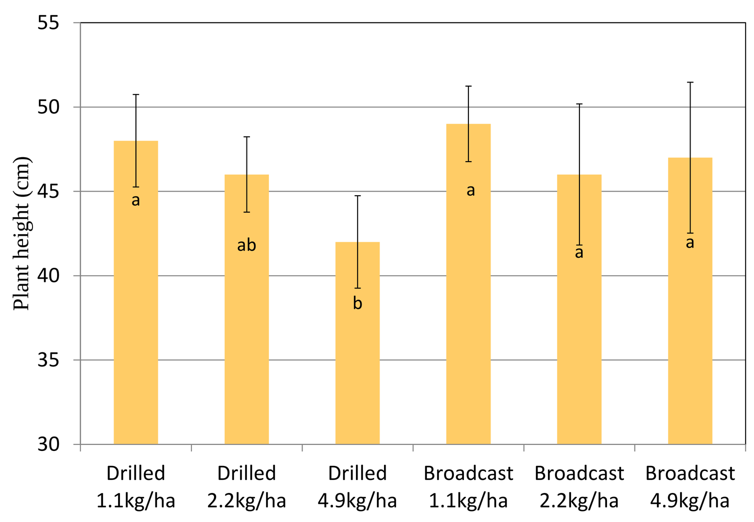

Figure 5. Plant heights for broadcast and drilled plots at three seeding rates. Different letters in bar graphs indicate significant differences at the P<0.05 level.

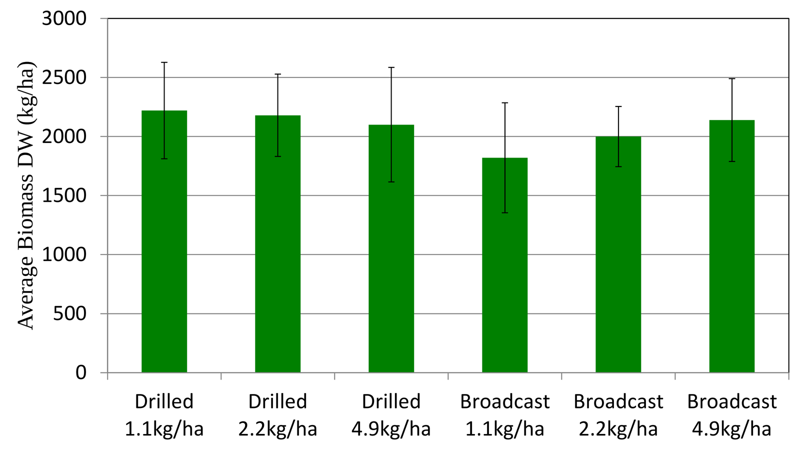

Figure 6. Total biomass yield for broadcast and drilled plots at three seeding rates.

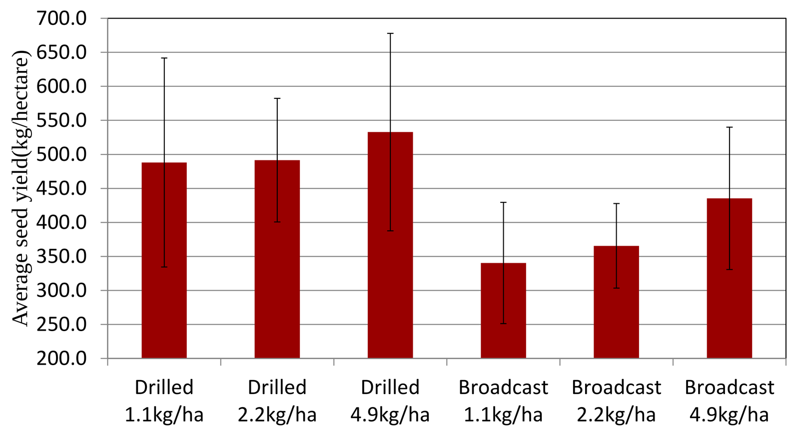

Figure 7. Average seed yield per hectare for broadcast and drilled plots at three seeding rates.

MATERIALS AND METHODS

Field Studies: On April 1st, 2010, pennycress breeding line 'Spring 32' was drilled and broadcast at rates of 1.1, 2.2, and 4.9 kg of seed per hectare at the Western Illinois University research farm in Macomb, Illinois (Figure 1). Each planting rate was replicated 5 times for both broadcast and drilled plots in a randomized split block design. Plot size measured 1 m by 3.5 m. Drilled plots were established by a Hege 1200 drill/planter consisting of 9 rows, 7.5 cm apart at a depth of 1 cm (Figure 2). Broadcast plots were achieved by removing the drop tubes from the drill and allowing seed to spread on the bare ground. All plots were maintained throughout the spring by hand weeding. One square meter was harvested by hand from each plot 79 days after planting on June 18th (Figure 3). Total seed yield, plant height, total seed oil content, and oil constituents were collected for each plot.

Oil and Data Analysis: Total oil content was determined by nondestructive pulsed NMR (Bruker Minispec PC 120, 180-mm absolute probe head) on whole pennycress seed. Medium-chain triglycerides were extracted and derivatized into fatty acid methyl esters for gas chromatography analysis. The fatty acid methyl esters were analyzed using an Agilent 5890 gas chromatograph with a flame ionization detector. Data was analyzed using analysis of variance (ANOVA) with statistical differences declared at P<0.05.

RESULTS AND DISCUSSION

Although pennycress is being considered as a winter annual and is normally planted in the fall, a non-dormant spring line, 'Spring 32', was utilized in this study to accommodate a spring planting study. The spring lines are characterized by a short height and less seed yield.

Pennycress line 'Spring 32' showed an increase in establishment rates from 21.7, 28.1, and 42.7% as seeding rates decreased from 4.9, 2.2, and 1.1 kg/ha, respectively for the drilled plots (Figure 4). A much poorer stand establishment occurred for the broadcast plots with rates increasing only slightly from 12.1, 17.0, and 25.8% for the decreasing seeding rates, respectively. As established population size increased, there was a significant decrease in plant height for the drilled plots but not in the broadcast plots (Figure 5). This may be the result of less resource competition due to smaller population sizes.

Figure 8. High density drilled planting of pennycress demonstrating no branching of plants.

Figure 9. Low density broadcast planting of pennycress demonstrating an increase in branching of plants.

The overall biomass yield across the different planting methods and seeding rates were found not to be significantly different (Figure 6). Unfortunately due to the tremendous variation seen between replicated plots, no significant differences could be seen for total seed yield (Figure 7). As population densities decreased, the amount of branching and thus total biomass increased due to less competition for resources (Figure 8 and 9).

Total seed oil yields varied only slightly from 28 to 29% and were found not to be significantly different for either planting method or across the varying seeding rates (Figure 10). No significant differences could be seen in the fatty methyl esters of linolenic, oleic, or erucic acid (Figure 11). Average number of seeds per pod, pods per plant, and 1000 seed weights were all found not to be significantly different across all treatments (Data not shown).

Figure 3. Total biomass yield for broadcast and drilled plots at three seeding rates.

CONCLUSIONS

Although total seed oil yield differences were found between drilled and broadcast plots, the overall rate of maturity of the drilled plots was much quicker. Producers might be able to seed at lower rates to receive similar seed yields, the delay in harvesting of pennycress and planting of the subsequent soybean crop might urge producers to plant at higher rates for more stand uniformity. Further studies need to be conducted exploring a greater range of seeding rates across multiple growing seasons, along with the impact of nutrients on stand establishments.

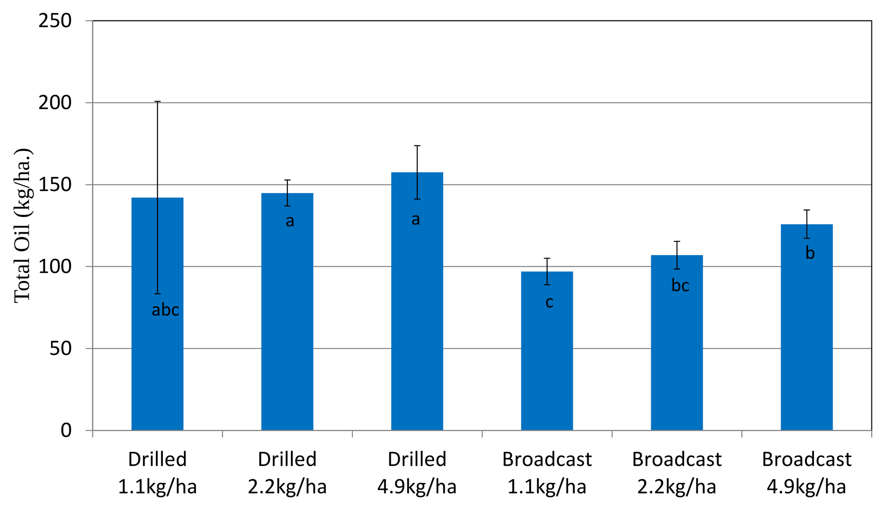

Figure 10. Average total seed oil yield per hectare for pennycress line 'Spring 32' across broadcast and drilled plots at three seeding rates. Different letters in bar graphs indicate significant differences at the P<0.05 level.

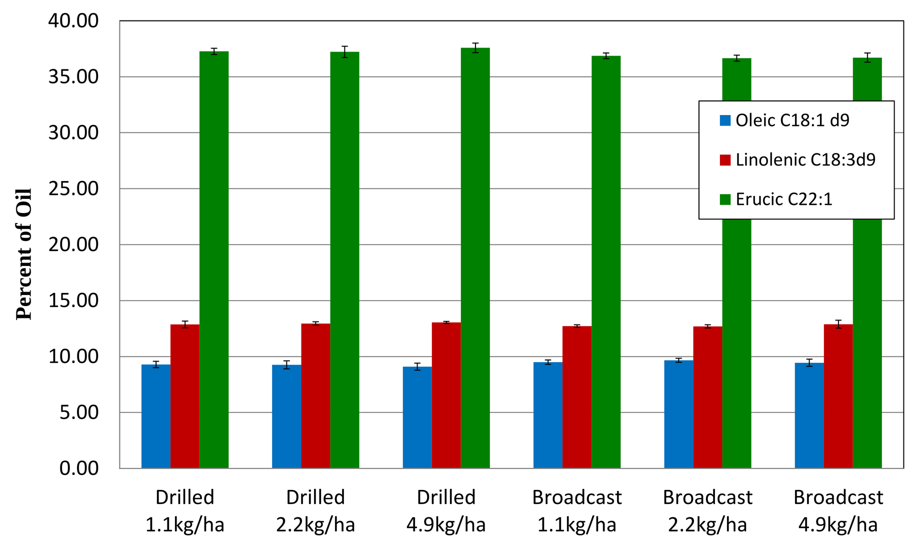

Figure 11. Fatty acid methyl esters for pennycress line 'Spring 32' across broadcast and drilled plots at three seeding rates.

LITERATURE CITED

Clopton, J.R. and H.O. Triebold. 1944. Fanweed seed oil: potential substitute for rapeseed oil. Ind. Eng. Chem. 36:218-219.

Gesch, R.W., Forcella, F., Barbour, N., Phillips, B., Voorhees, W.B. 2003. Growth and yield response of Cuphea to row spacing. Field Crops Res. 81, 193–199.

Moser, B.R., G. Knothe, S.F. Vaughn, and T.A. Isbell. 2009. Production and evaluation of biodiesel from field pennycress (*Thlaspi arvense* L.) Oil. Energy and Fuels, 23:4149-4155.

Van Dyne, D.L., M.G. Blase, and K.D. Carlson. 1990. Industrial feedstocks and products from high erucic acid oil: crambe and industrial rapeseed. Univ. Missouri-Columbia, Columbia, MO.

Vaughn, S.F., T.A. Isbell, D. Weisleder, and M.A. Berhow. 2005. Biofumigant compounds released by field pennycress (Thlaspi arvense) seedmeal. Journal of Chemical Ecology 31(1): 167-177.

Vaughn, S.F., D.E. Palmquist, S.M. Duval, and M.A. Berhow. 2006. Herbicidal activity of glucosinolate-containing seedmeals. Weed Science 54 (4):743-748.

RESEARCH FUNDING

This project was supported by the Agriculture and Food Research Initiative competitive grant # (2010-85117-20535) of the USDA National Institute of Food and Agriculture.