

Planting Date, Herbicide, and Soybean Rotation Studies with Field Pennycress (*Thlaspi arvense* L.)

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ABSTRACT

Thlaspi arvense L. (field pennycress) is a new crop being investigated for its potential as a possible off season source for biodiesel and as an additive to petroleum based products in the Midwest. For pennycress to be successfully adopted by producers, off season production must have minimal impact on the current crop rotations.

One objective of this study was to determine the optimal fall planting date for field pennycress in Illinois to maximize seed yield in early spring. Other objectives were to identify potential herbicides for pennycress production and to assess the impact of pennycress residue on subsequent soybean crops.

During the fall of 2009, the winter line 'Patton' was planted in replicated plots from September 1st to November 3rd. In spring 2010, each plot was evaluated for seed yield, total seed oil, fatty acid methyl ester content, along with several other agronomic traits. Replicated herbicide trials with active ingredients alachlor (Intro), pendimethalin (ProwlH2O), and clopyralid (Stinger) at three different labeled rates were conducted across 2 growing seasons. Replicated soybean plots were planted following pennycress across 5 planting dates in 2009 and 2010. Soybeans were evaluated for seed yield, stand establishment, seed protein and oil quality and compared to soybeans following fallow ground.

Planting dates when soil temperatures were above 15.5°C resulted in an average of 1,568 kg ha⁻¹. Seed yields declined steadily as soil temperatures drop to 10°C. Below 10°C, fall planted pennycress seed did not germinate until spring. Total oil steadily declined while fatty methyl esters remained uniform across planting dates. Alachlor and pendimethalin demonstrated the least amount of pennycress injury. Pennycress rotation with soybeans resulted in no impact on soybean stand establishment or protein and oil quality across all five planting dates.

Early fall planting, the potential for herbicide use, and no impact on following soybeans helps pennycress move forward as a viable crop in the Midwest.



Figure 1. Planting date study at Macomb, Illinois. Photo taken April 7, 2010.

INTRODUCTION

Development of diverse and renewable feed stocks for the production of fuel will become a most certain priority for the U.S. agriculture sector. However, displacement of crops that produce the world's food from tillable land is a concern. One approach to solve both needs for food and fuel is to rotate both types of crops through the same land in one extended growing season. The potential new crop, field pennycress (*Thlaspi arvense* L.) offers a short winter growing season allowing 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). Pennycress grown as a winter annual forms a rosette of leaves up to 6" across throughout the winter months with a central stem and several side stems terminating in erect racemes of small white flowers in early spring (Warwick et al., 2002). Flowers are pre-dominantly self-pollinated and produce up to 14 seeds that are half the size of a canola seed with a 1000 seed weight of 0.83 grams. The seed was found to have 36% oil with the major fatty acid as erucic at 38.1%, iodine value of 115 (Moser et al., 2009). Wild stands can approach 2,000 pounds of seed per acre.

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.

The objectives of this study were to determine the optimal fall planting date for field pennycress in Illinois to maximize seed yield in early spring. Other objectives were to identify potential post emergent herbicides for spring weed control and to assess the impact of pennycress residue on subsequent soybean crops.



Figure 10. Soybeans drilled into pennycress stubble replicated across five planting dates.

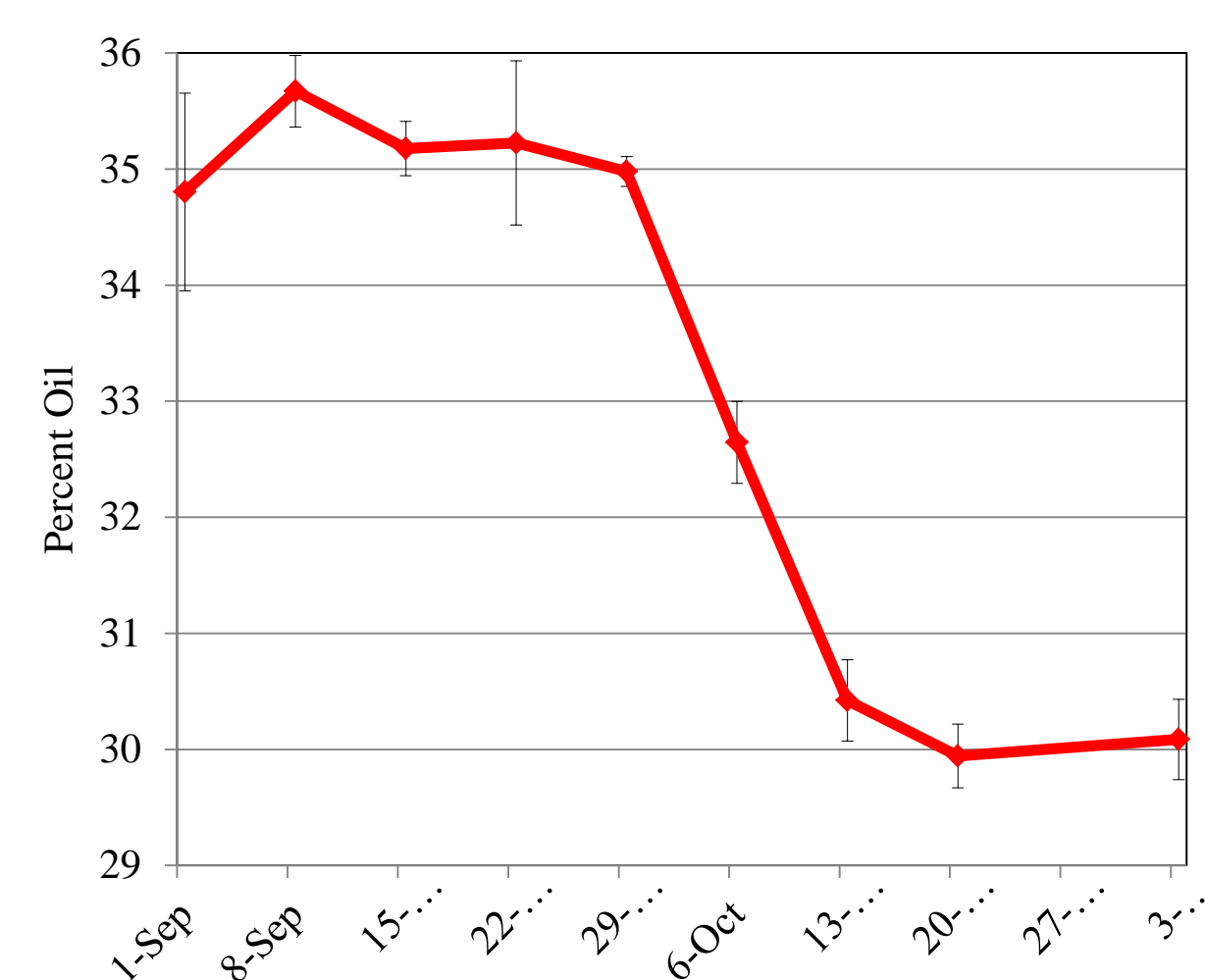


Figure 2. Total seed oil yield for pennycress line 'Patton' across different fall planting dates.

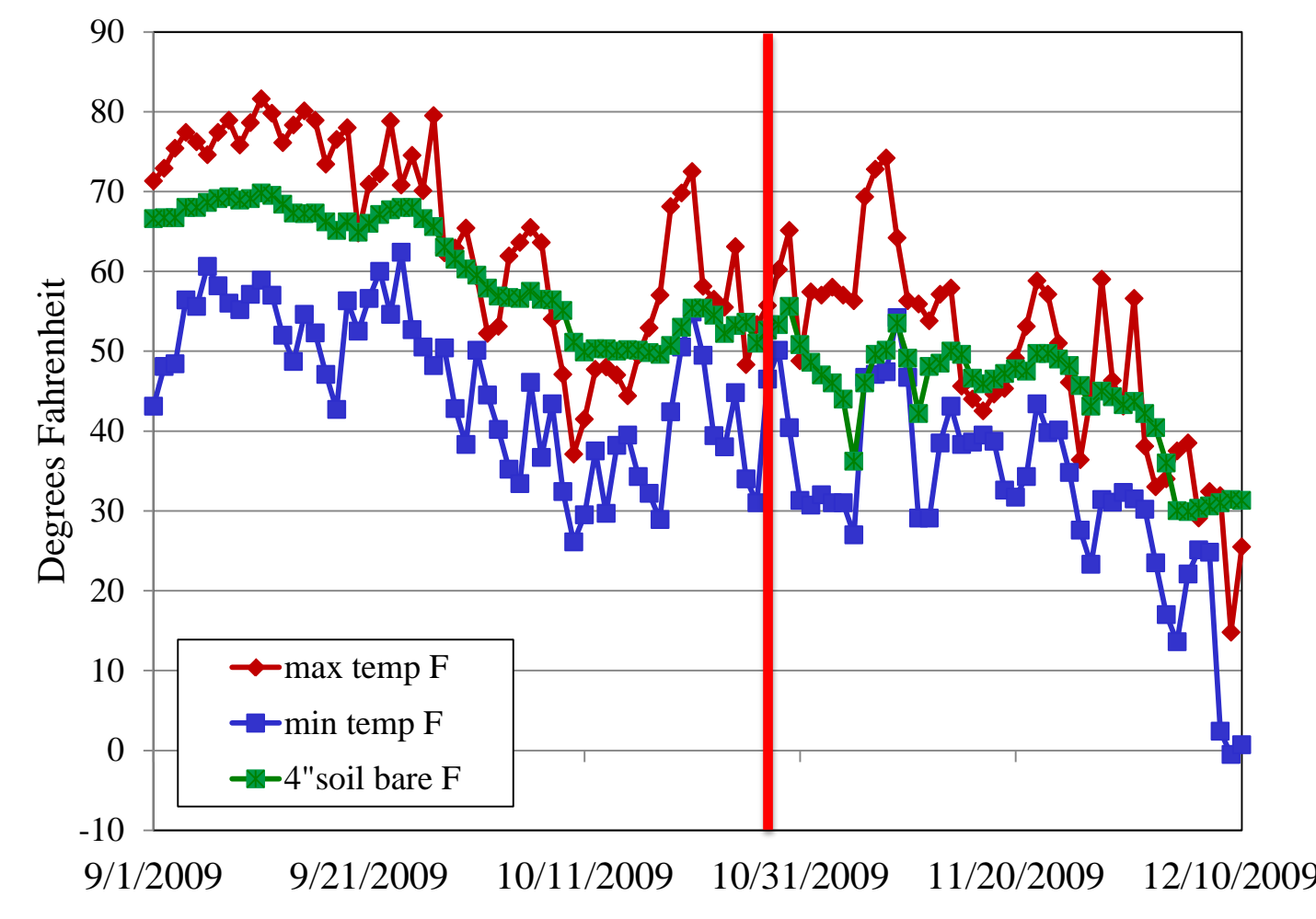


Figure 3. Minimum air temperature, maximum air temperature, and 4" bare soil temperature data collected during planting date study.

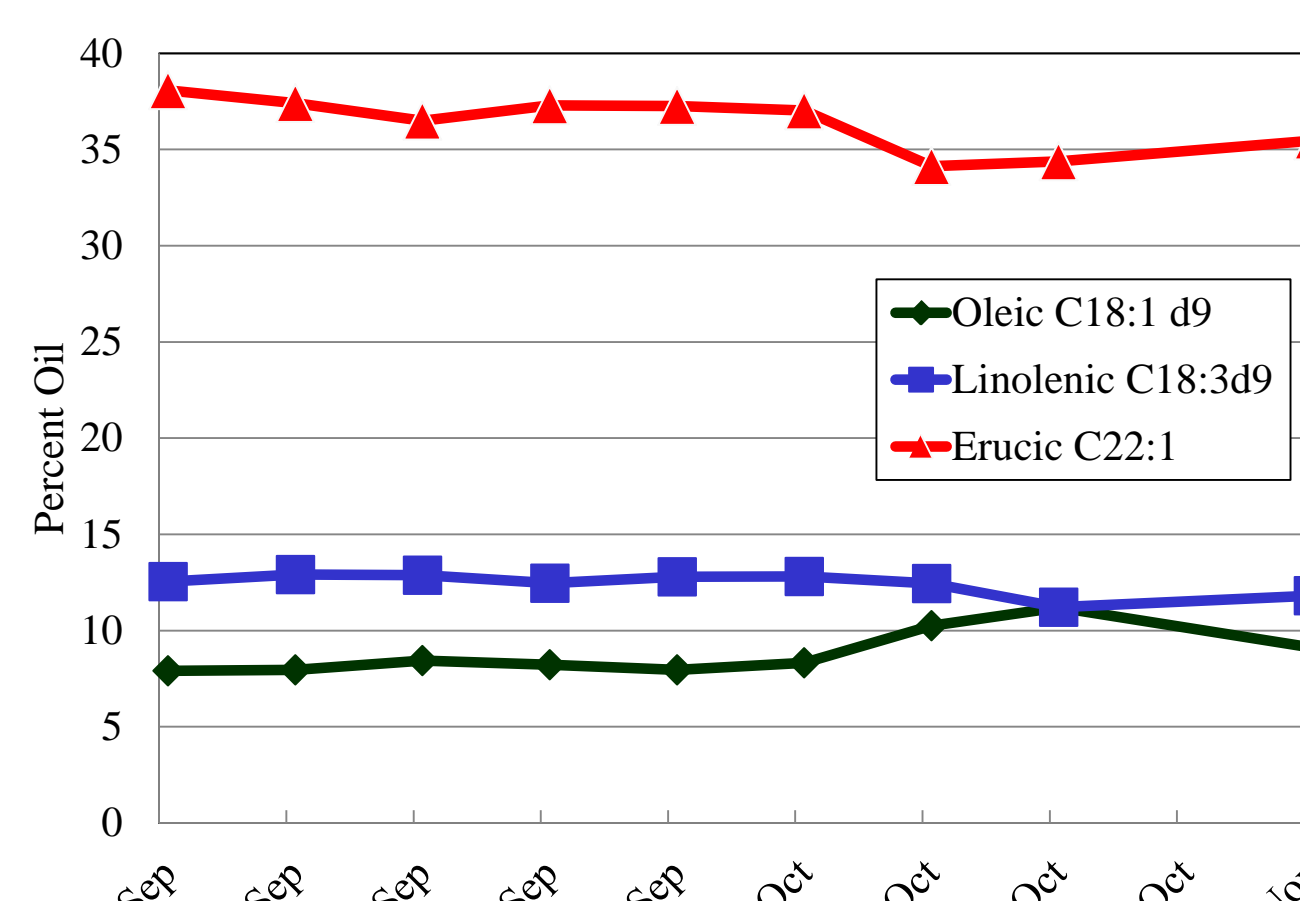


Figure 4. Variation of seed oil fatty acids across planting dates.



Figure 5. Photo of planting date study indicating variation in plant maturity at time of first harvest May 24.

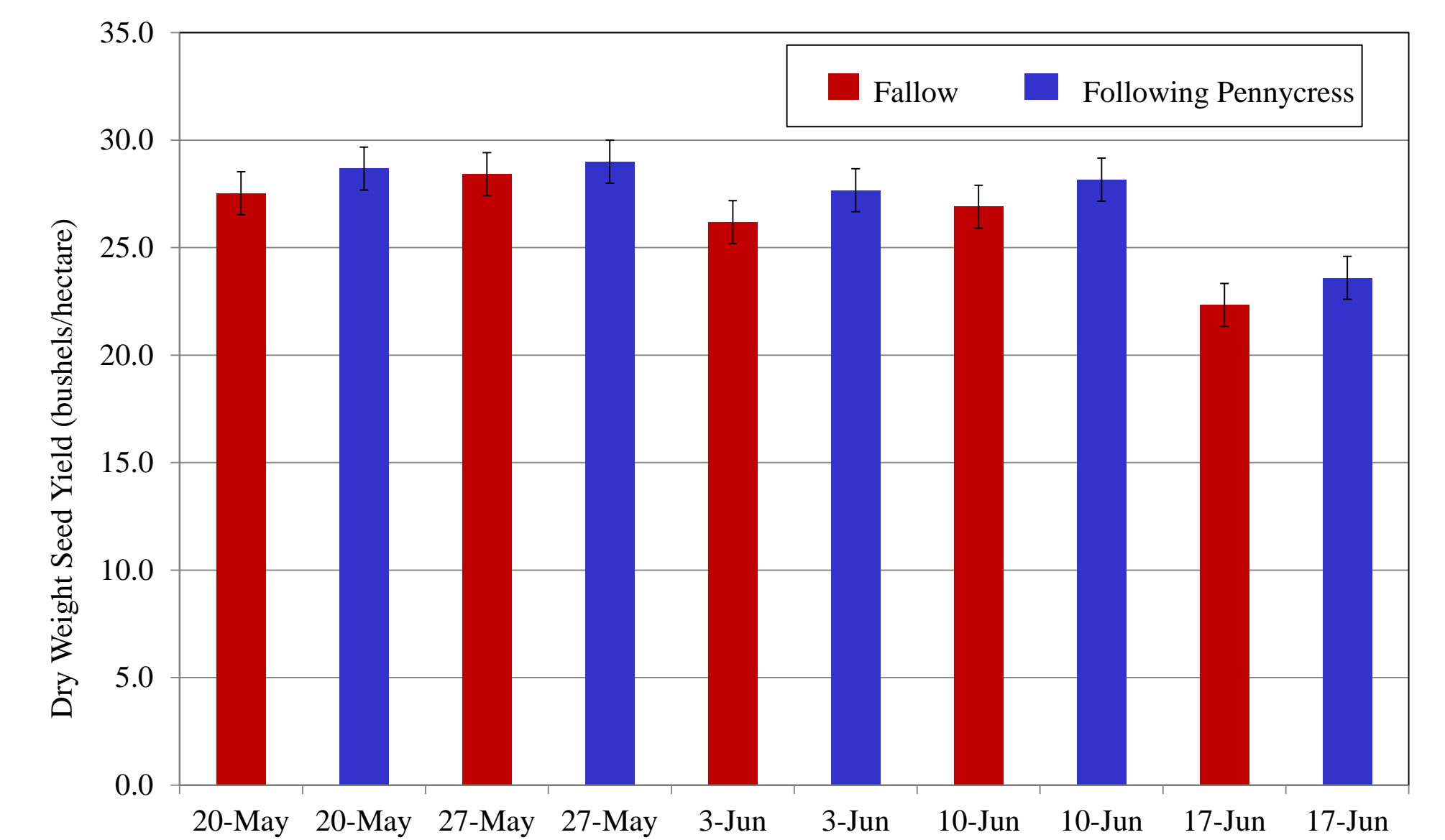


Figure 9. Dry bushel yield for soybeans across 5 planting date in 2009

Table 1. Protein and seed oil analysis of soybeans planted after pennycress and fallow ground in 2009.

Planting Date and Treatment	Percent Protein	Percent Oil	Palmitic Acid	Stearic Acid	Oleic Acid	Linoleic Acid (o6)	Alpha Linolenic Acid (o3)
			C16:0	C18:0	C18:1	C18:2	C18:3
May 20 - Control	40.6	20.2	12.6*	3.7	20.4	54.8	8.5
May 20 - Pennycress	39.6	20.0	12.6	3.7	20.9	54.3	8.4
May 27 - Control	39.9	20.5	12.7	4.1	20.7	53.6	9.0
May 27 - Pennycress	40.4	20.3	12.5	3.9	20.8	54.4	8.5
June 3 - Control	40.0	20.3	12.4	4.3	22.3	52.5	8.5
June 3 - Pennycress	40.5	20.4	12.7	3.8	21.2	53.8	8.5
June 10 - Control	39.4	19.6	12.6	3.9	22.5	52.1	8.9
June 10 - Pennycress	39.7	19.9	12.9	3.7	22.0	52.8	8.5
June 17 - Control	39.2	19.5	12.2	3.7	19.6	55.1	9.4
June 17 - Pennycress	39.3	19.4	13.3	3.4	19.2	54.3	9.8

*Percentage of total seed oil by weight.

MATERIALS AND METHODS

Plant Date Study: Pennycress line 'Patton' was planted in Macomb, IL over 9 separate weeks in the fall of 2009 from September 1st to November 3rd (Figure 1). Each planting date plot consisted of 9 drilled rows 7.5 cm apart and 3.5 m long. Each planting date was replicated 4 times and maintained by hand weeding. One square meter was harvested by hand from each plot in late May and early June and analyzed for seed yield, total oil content, and oil constituents. Weather data was collected at the planting site.

Herbicide Trials: In fall 2008 and 2009, the pennycress line 'Patton' was drilled into 30 plots measuring 3.1 m by 4.5 m. Just prior to flowering in early April of the following spring, rates of half, 1x, and 2x labeled rate were applied for each of the herbicides containing the active ingredients alachlor (Intro), pendimethalin (ProwlH2O), and clopyralid (Stinger). Each rate was replicated three times with plots receiving no herbicides serving as a control. Plots were evaluated 14 days after herbicide application for plant injury. Sub-samples were harvested from each plot measuring 1.5 m x 3.0 m and analyzed for seed yield, total oil content, and oil constituents.

Soybean Rotation Studies: In spring 2009 and 2010, Pioneer '93M11' soybeans were drilled into pennycress stubble for five consecutive weeks from mid May to late June. Prior to each planting date, pennycress was cut by a string trimmer with all material remaining in the field. Control plots were planted on fallow ground following wheat the previous season. Both pennycress and control plots were replicated three times on the same Ipava soil type. All plots were hand harvested in late fall and analyzed for oil and protein profiles.

Oil, Protein, and Data Analysis: Total oil content was determined by nondestructive pulsed NMR (Bruker Minispec PC 120, 180-mm absolute probehead) 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 6890 gas chromatograph with a flame ionization detector. Soybean protein was evaluated using NIR (Near Infrared Reflective) Spectroscopy. Data was analyzed using analysis of variance (ANOVA) with statistical differences declared at P<0.05.



Figure 8. Herbicide injury seen 14 days after treatment with 1x clopyralid.

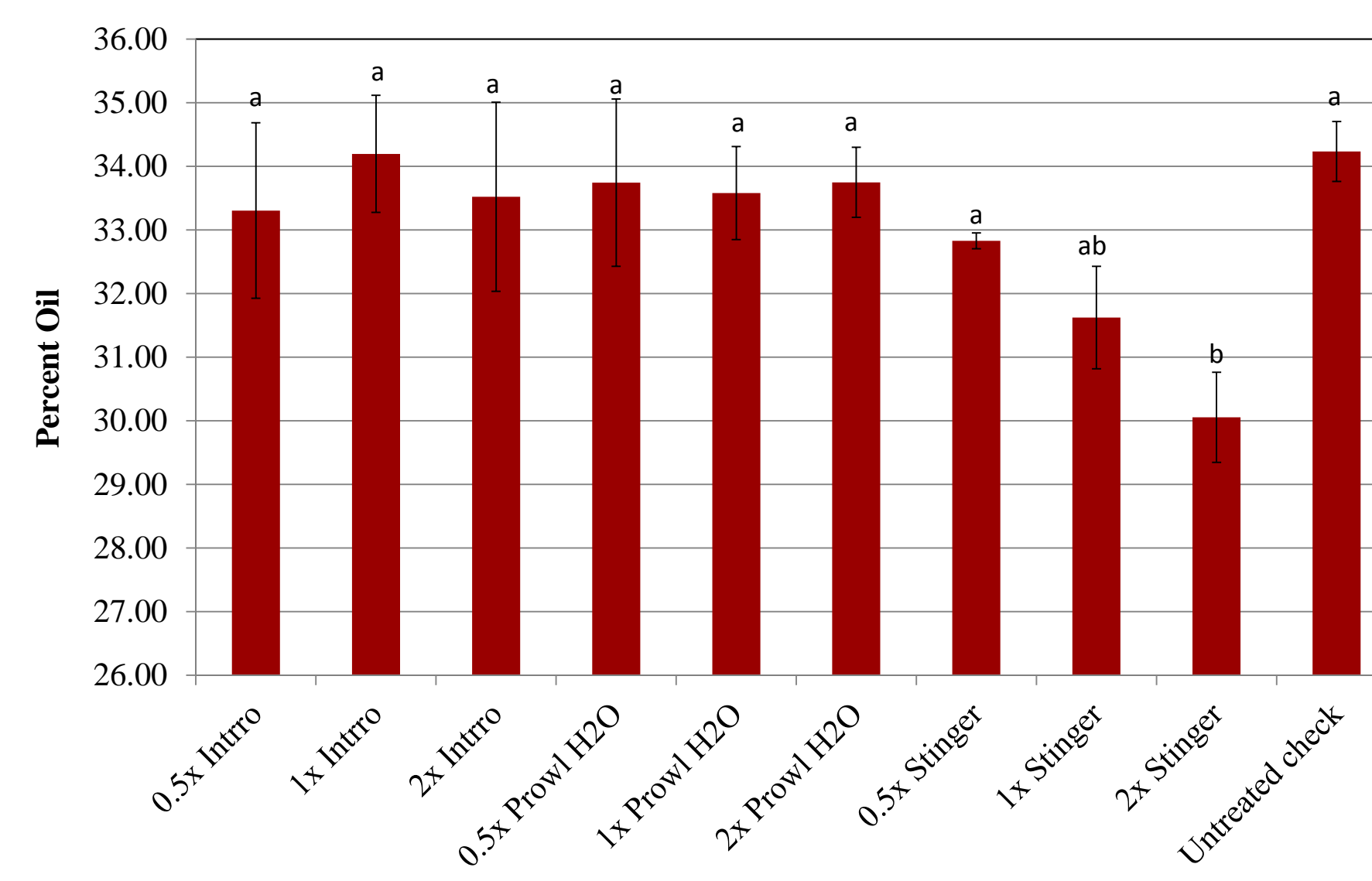


Figure 7. Total seed oil yield in 2009 after herbicide treatments. Different letters atop bar graphs indicate significant differences at the P<0.05 level.

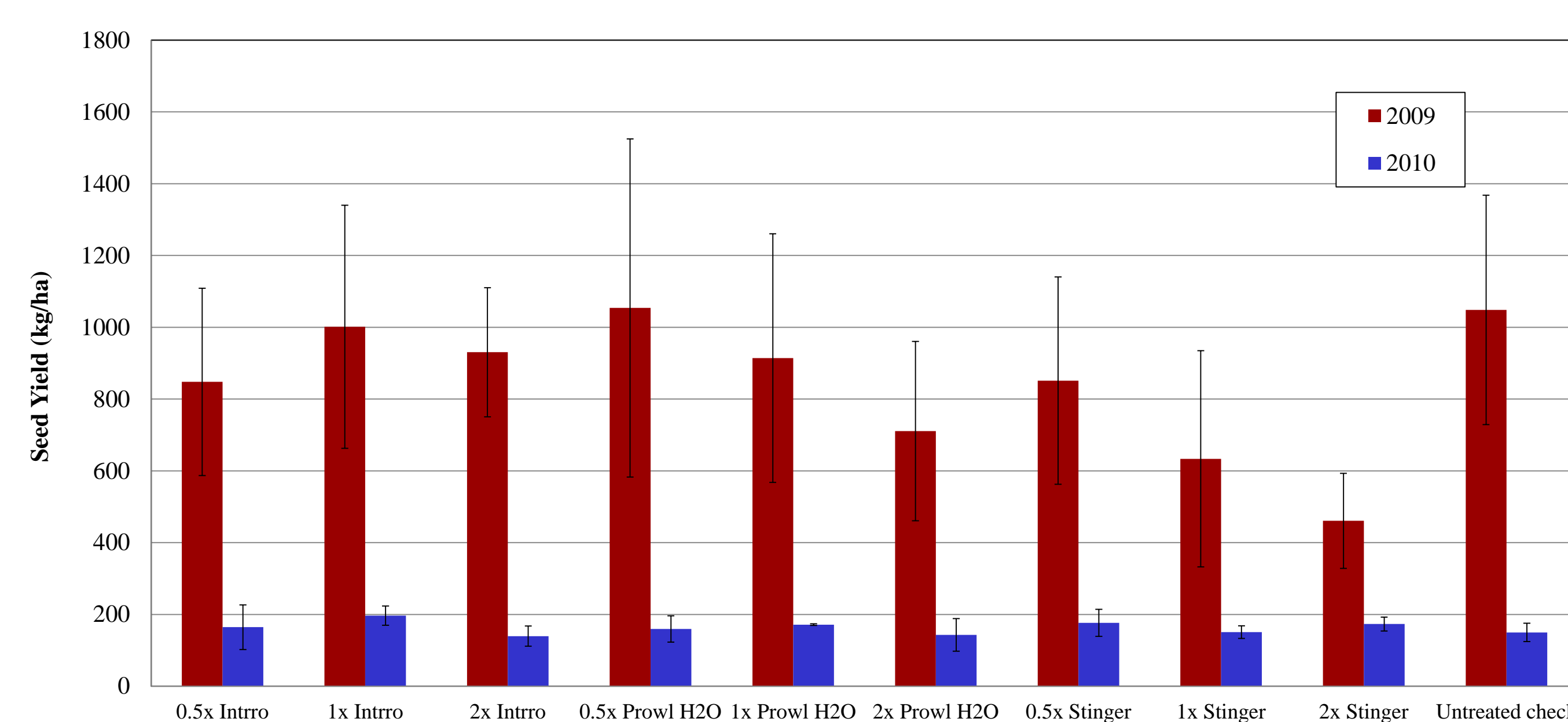


Figure 6. Total seed yield following herbicide treatments in 2009 and 2010.

RESULTS AND DISCUSSION

Plant Date Study: The first five planting dates occurring in September were not found to be significantly different from each other in terms of total seed oil content (Figure 2). However, as soil temperatures declined throughout the fall (Figure 3), stand establishment declined resulting in a significant decrease in seed and total oil yield. The percentage of seed oil constituents remained constant for the September planting dates, with erucic acid levels declining and oleic acid levels increasing towards the later planting dates (Figure 4). The early establishment of the September planting dates also allowed for harvest on May 24th, while later planting dates were harvested on June 11th (Figure 5).

Herbicide Trials: The 2010 growing season was extremely wet and cold resulting in a poor stand establishment leading to very low yields overall (Figure 6). However, 2009 resulted in significant differences between herbicide applications (Figure 7). Herbicide injury was noticed on all treated plants (Figure 8), however only 1x and 2x rates of clopyralid (Stinger) resulted in significant yield loss when compared to the control. No significant differences were found in total seed oil or oil constituents across all herbicide treatments.

Soybean Rotation Studies: All five planting dates of soybeans following pennycress resulted in slightly higher yields when compared to the control plots (Figure 9). The slight bushel increase following pennycress may have been the result of increased soil moisture due to higher ground cover. Soybeans were planted directly after cutting pennycress (Figure 10). No significant differences could be found in either seed oil constituents or protein profiles between soybeans following fallow ground and soybeans following pennycress (Table 1).

CONCLUSIONS

Identifying an ideal September planting season will significantly improve a producer's chance of harvesting high yielding pennycress prior to planting soybeans. Applications of alachlor and pendimethalin based herbicides show promise in helping control weeds and minimizing impact on pennycress seed yield. No adverse effects have been seen in soybeans following pennycress production. With excellent biodiesel properties, a very short growing season, and no impact on subsequent soybeans, pennycress offers tremendous opportunities for producers to diversify and capitalize on diminishing the US demand for foreign based oils.

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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.

