FIELD PENNYCRESS (*Thlaspi arvense* L.) RESPONSE TO NITROGEN AND SULFUR RATES

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ABSTRACT

Field pennycress (*Thlaspi arvense* L.) is a new potential oilseed crop that is currently being evaluated as a domestic source of biodiesel fuel. Knowledge of pennycress nitrogen requirements will help producers apply optimal nitrogen and sulfur rates while minimizing production costs.

This study was initiated to evaluate the effect of nitrogen and sulfur fertilization rates on pennycress plant height, pod number, seed and biomass yield, and oil content and quality. Two growth chamber experiments were conducted on spring and winter annual pennycress lines, 'Spring 32' and 'W12', with six nitrogen rates (0, 25, 50, 75, 100, and 125 lbs. nitrogen per acre) and two sulfur rates at 10 and 25 lbs. per acre. Each study was replicated twice over 1 year.

Nitrogen fertilizer rate was a significant factor influencing plant height, pod and seed number per plant, seed and biomass yield for both the spring and winter lines of pennycress. A rate of 100 lbs. of nitrogen resulted in the greatest number of pods and seeds per plant, 83 and 650 respectively. Nitrogen fertilization had no effect on the number of seeds per pod, 1000 seed weight, harvest index, total oil content, and fatty acid constituents. Seed yields increased significantly for 100 and 125 lbs. of nitrogen per acre in combination with 25 lbs. of sulfur. Winter and spring pennycress lines were not significantly different from each other in response to increasing nitrogen rates. Overall nitrogen use efficiency decreased with increasing nitrogen rates.

Understanding the ideal nitrogen and sulfur levels for pennycress to obtain optimal yields will further improve a producer's ability to successfully integrate this new crop into the already well-established corn and soybean rotation in the Midwest.

Figure 1. Field pennycress 'W12' plants in growth chamber experiment evaluating effects of nitrogen and sulfur rates.

INTRODUCTION

Field pennycress (*Thlaspi arvense* L.) is a new potential oilseed crop that is currently being evaluated as a domestic source of biodiesel fuel. Pennycress belongs to the *Brassicaceae* family and grows as a common weed throughout the temperate climate in North America. The seed contains between 20-36 wt % of oil with high levels of erucic, linoleic, and other unsaturated fatty acids (Moser et al., 2009). This oil profile enables production of biodiesel with a high cetane number and excellent low temperature properties.

Nitrogen is one of the most expensive agricultural inputs in oilseed production (Gan et al., 2008). Literature indicates that important oilseed crops from the *Brassicaceae* family, like rapeseed and canola, have high demands for nitrogen (Balint at al., 2008; Gan et al., 2008). Currently, no information is available on the response of pennycress to nitrogen, sulfur, and other nutrients. Understanding and improving N-efficiency of pennycress will reduce the potential for environmental pollution and improve economic returns (Grant and Bailey, 1993). In terms of the environment, the crop should receive optimum doses of N to ensure yield development and avoid subsequent N-leaching from the soil.

Growth chamber experiments were initiated to evaluate the effect of nitrogen and sulfur fertilization rates on pennycress seed and biomass yield, yield components, and seed oil content and constituents for both winter and spring type pennycress lines. Nitrogen use efficiency was also determined.

Figure 2. Field pennycress 'Spring 32' plants near maturity in growth chamber experiment evaluating effects of nitrogen and sulfur rates on plant height.

Table 1. Mean values of pennycress plant and seed data obtained with six nitrogen fertilization treatments using spring type 'Spring 32' pennycress.

N*	Plant height (cm)	Number pods per plant	Number seeds per plant	Seed mass (g)	Dry bio-mass (g)	Number seeds /pod	1000 Seed weight (g)	Harvest Index (%)	Total oil content (%, dry weight basis)	Oleic acid content (%)	Linolenic acid content (%)	Erucic acid content (%)
0	26.2a$	17a	119a	0.11a	0.22a	7	0.88	36	33.7	9.3	15.4	33.5
25	32.8ab	56b	395b	0.32b	0.57b	7.1	0.81	39	33.6	11.3	14.4	32.4
50	35.1ab	71c	468b	0.43c	0.75bc	6.6	0.95	38	34.0	9.1	14.0	34.5
75	36.2ab	76c	519bc	0.51cd	0.93c	6.8	1.01	36	32.9	10.3	13.5	33.4
100	37.1b	83c	650c	0.59cd	1.06c	7.8	0.98	36	31.4	9.0	13.3	33.5
125	37.7b	83c	648c	0.61d	1.16c	7.8	1.02	36	32.7	10.7	14.5	32.0

*, N= nitrogen rate (lbs./acre)

$, Within columns, means followed by the same letters are not significantly different at 0.05 probability level. Columns with no letters are not significant.

Table 2. Mean values of pennycress plant and seed data obtained with combinations of nitrogen and sulfur fertilization treatments using winter type 'W12' pennycress.

N*	S	Plant height (cm)	Number pods per plant	Number seeds per plant	Seed mass (g)	Dry bio-mass (g)	1000 Seed weight (g)	Harvest Index (%)
0	0	25.0a$	14a	87a	0.08a	0.18a	0.97	34
25	0	33.8b	39b	261b	0.22b	0.53b	0.89	30
50	0	37.1b	51b	329abc	0.31b	0.57bc	1.02	32
75	0	36.5b	62b	443bc	0.41b	0.72c	0.91	35
100	0	38.0b	63b	480bc	0.45bc	0.86bc	0.99	34
125	0	37.5b	66b	505c	0.48bc	0.83bc	1.02	37
0	10	20.9a	19a	132a	0.13a	0.18a	1.00	43
25	10	29.6b	54b	338b	0.30b	0.43b	0.88	41
50	10	36.8c	73b	554bc	0.45c	0.81c	0.80	35
75	10	32.6b	85b	622bc	0.52c	0.84cd	0.84	38
100	10	32.2b	71b	579c	0.52c	0.91cd	0.91	37
125	10	36.1c	82b	554c	0.52c	0.97d	0.95	35
0	25	23.3a	19a	136a	0.14a	0.25a	1.05	36
25	25	30.3b	44b	300b	0.25b	0.41b	0.84	38
50	25	32.8c	84c	572c	0.46c	0.89c	0.79	33
75	25	37.7d	100cd	709d	0.60d	1.05cd	0.84	36
100	25	39.2e	97cd	765d	0.64d	1.15d	0.83	35
125	25	38.1de	101cd	826d	0.64d	1.22d	0.77	34

*, N= nitrogen rate (lbs./acre): S = Sulfur rate (lbs./acre)

$, Within columns, means followed by the same letters are not significantly different at 0.05 probability level. Columns with no letters are not significant.

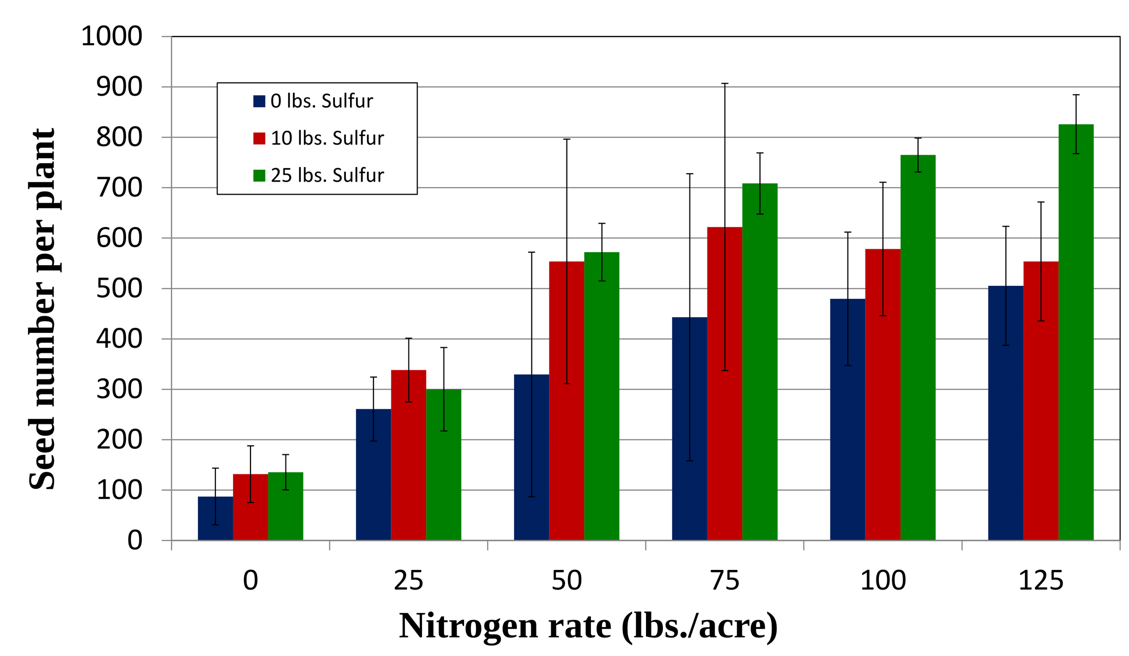

Figure 3. Total seed number per plant across increasing nitrogen and sulfur rates for winter line 'W12' pennycress.

MATERIALS AND METHODS

Growth Chamber Experiment:

A growth chamber experiment was conducted using a non-dormant spring pennycress, 'Spring 32', and a dormant winter line, 'W12'. Growth chamber conditions were set to an 18 hour photoperiod (7.9μE/m²/sec) with day/night temperatures of 24°C and 20°C, respectively. After germination, five uniform seedlings were transplanted into individual 7.5 cm square pots containing nitrogen rates of 0, 25, 50, 75, 100, and 125 lbs. of nitrogen per acre for the spring line. The same protocol was followed for the winter line but also included nitrogen rates in combination with 10 and 25 lbs. of sulfur. The winter line required 20 days of cold treatment at 4°C to induce flowering. The source of nitrogen was granulated urea fertilizer (46-0-0), and the source for sulfur was Disper-Sul (90%). Fertilizer was applied at the time of seedling transplant by hand. A wicking system was used throughout the experiment to adequately water the plants (Figure 1). Sixty days after transplanting, the plants were hand harvested at the time of full maturity (Figure 2).

Oil, Plant, and Data Analysis:

Total oil and fatty acid methyl ester content was determined utilizing an Agilent 6890 gas chromatograph with a flame ionization detector. Nitrogen % in seed and dry matter was determined by a LECO CHN2000 analyzer. Nitrogen use efficiency was calculated as seed yield (g) produced per unit of N supply (g), that is, NUE=seed yield/(Nt + Nf). Nt equals N derived from soil as determined by N uptake in seed + straw in control plots where zero-N fertilizer was applied, and Nf equals amount of N from fertilizer. Analysis of variance (ANOVA) was performed by Excel software.

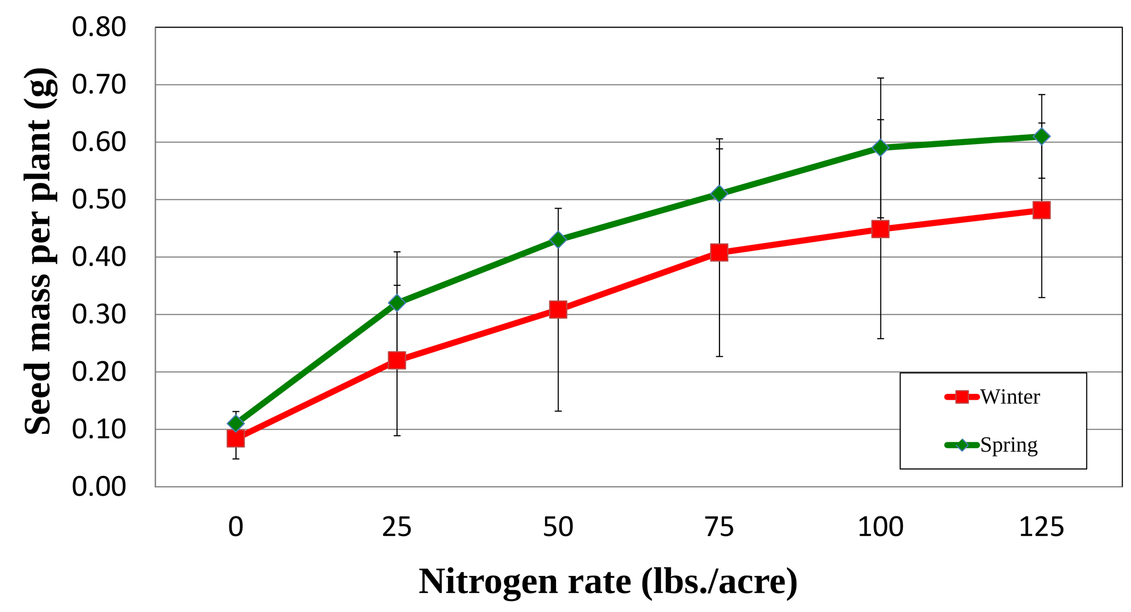

Figure 4. Total seed mass per plant across increasing nitrogen rates for winter and spring lines of pennycress.

RESULTS

Nitrogen fertilizer rate was a significant factor influencing plant height, pod and seed number per plant, and seed and biomass yield for both the spring and winter lines of pennycress (Tables 1 and 2). Nitrogen fertilization had no effect on total oil content and fatty acid constituents. Seed yields increased significantly for 100 and 125 lbs. of nitrogen per acre in combination with 25 lbs. of sulfur (Figure 3). Winter and spring pennycress lines were not significantly different from each other in response to increasing nitrogen rates (Figure 4). Overall nitrogen use efficiency decreased with increasing nitrogen rates (Figure 5).

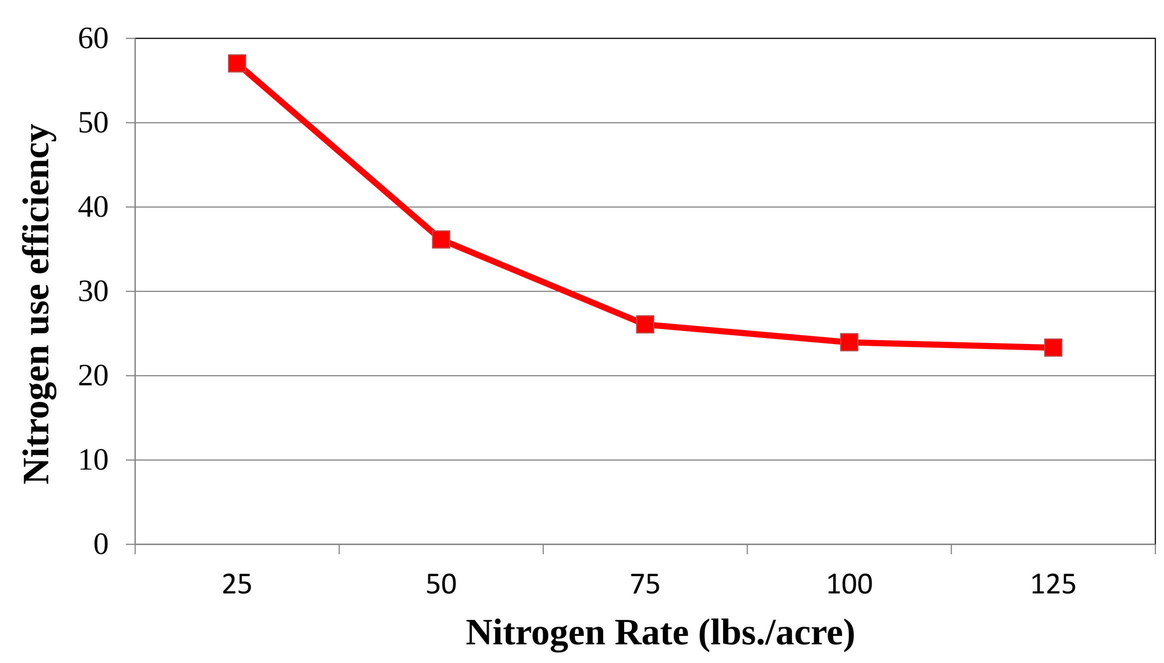

Figure 5. Nitrogen use efficiency for 'Spring 32' field pennycress.

CONCLUSIONS

Spring and winter pennycress lines demonstrated similar responses to increasing nitrogen rates. The addition of 25 lbs. per acre of sulfur was only significant at the highest nitrogen rates of 100 and 125 lbs. per acre. Seed yield achieved at the nitrogen rate of 50 lbs. per acre was not significantly different than higher nitrogen rates. Understanding and improving N-efficiency of pennycress through breeding and selection will help reduce the potential for environmental pollution and improve economic returns for producers. Minimizing nitrogen inputs will also aid in establishing pennycress as a viable biofuel and cover crop.

LITERATURE CITED

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