

FLAX RESPONSE TO NITROGEN AND SEEDING RATES

Greg Endres, Bryan Hanson, Mark Halvorson, Blaine G. Schatz, and Bob Henson

Introduction

Current North Dakota State University nitrogen (N) recommendations for flax production are three lbs. N/acre for each bushel of yield goal (1). Seeding rate recommendations range from 20 to 45 lbs./acre, depending on yield potential (2). A stand of 70 plants/ft² may optimize yield potential.

The objectives of this trial were:

- ◆ Determine flax lodging and yield response to increasing soil N levels and seeding rates (lb./acre and pure live seeds/acre).
- ◆ Determine the influence of soil N level on oil content, alpha linolenic acid concentration, and flavor of flax seed.

Materials and Methods

The field trial was conducted on loam soils in 2001-03 at the NDSU Research Extension Centers in Carrington, Langdon and Minot. Experimental design

was a randomized complete block with a split-plot arrangement and four replications. Main plots were soil N treatments and sub-plots were seeding rates. Soil N levels included an untreated check (soil NO₃-N < 60 lbs/acre sampled at the 0-24 inch depth) and 60, 90, and 120 lbs. N/acre (seed yield goals of < 20, 20, 30, and 40 bushels/acre, respectively). Pre-trial soil N levels varied by site-year: Carrington – 31 to 53 lbs./acre; Langdon – 37 to 50 lbs./acre; and Minot – 17 to 55 lbs./acre.

Fertilizer N was preplant broadcast applied to reach the selected soil N levels. ‘Cathay’ flax was seeded at 20, 32, and 44 lbs./acre, and also at 56 lbs./acre in 2002-03.

Results and Discussion

Trial average flax seed yield (across soil N and seeding rates) was less than 30 bushels/acre at all site-years. Average seed yield at Carrington by site-year ranged from 20.5 to 26.5 bushels/acre with a 3-year average yield of 23.8 bushels/acre (Table 1).

Table 1. Trial average seed yield by site-year, ND, 2001-03.

Year	Seed yield (bushels/acre)			
	Carrington	Langdon	Minot	<i>average</i>
2001	26.5	12.4	--	<i>19.5</i>
2002	20.5	17.4	9.5	<i>15.8</i>
2003	24.3	21.5	13.7	<i>19.8</i>
<i>average</i>	<i>23.8</i>	<i>17.1</i>	<i>11.6</i>	<i>--</i>

At Langdon, trial average seed yield by site-year ranged from 12.4 to 21.5 bushels/acre with a 3-year average of 17.1 bushels/acre (Table 1). In 2001, lodging that occurred at

Langdon because of heavy rain in late July and subsequent disease (pasm and Sclerotinia) reduced yield. A dry mid-summer period in 2002 and a dry 2003 growing season (three inches less rainfall compared to the long-term average) reduced yield potential. Also, at Langdon in 2002, the deep (24-48 inches) soil N test indicated 64 lbs./acre. According to NDSU recommendations, an additional N credit of 27 lbs./acre was available for flax in addition to N present at the 0- to 24-inch soil depth. This may explain the lack of flax yield response to soil N levels higher than the untreated check.

Agronomic data from Minot in 2001 are not presented or discussed due to variable plant stands caused by dry soil conditions after seeding. Trial average seed yield was poor each site-year at Minot (Table 1). Late seeding dates combined with average or below average growing-season rainfall and high late-summer temperatures resulted in low yield.

Soil N

Seed yield. Soil N affected flax seed yield at two of eight site-years (Table 2). At the two site-years, yield generally increased up to 90 lbs./acre of soil N. Plant lodging at each site-years generally did not differ among N rates (data not shown). The only exception was at Carrington in 2003, but lodging was minimal and had no effect on yield. Also, there was no significant soil N by seeding rate interactions for lodging or yield.

Table 2. Flax response to soil N (across seeding rates), Carrington and Langdon, 2003.

Soil N (lb/acre)	Seed yield (bushels/acre)		
	Carrington, 2003	Langdon, 2003	average
	check*	20.7a	10.6a
60	23.4ab	12.1b	17.8
90	25.5bc	15.6c	20.6
120	27.6c	16.6c	22.1
<i>LSD 0.05</i>	3.7	1.6	--

*untreated check soil N (0-24 inch depth): Carrington = 31 and Langdon = 50 lbs./acre.

Oil content. Seed oil content decreased with increased soil N in six of eight site-years (Table 3). Oil content generally decreased with soil N > 60 lbs./acre.

Table 3. Soil N affect on flax seed oil content, ND, 2001-03.

Soil N (lb/acre)	Seed oil (%)						
	Langdon 2001	Minot 2001	Carrington 2002	Minot 2002	Carrington 2003	Langdon 2003	average
check	39.7b	-	40.3a	43.1a	46.5a	43.8a	42.7
60	41.1a	42.1a	40.5a	43.3a	45.6b	43.6a	42.7
90	38.0c	41.3b	39.6b	42.8b	44.9c	42.3b	41.5
120	40.8a	41.6b	38.9c	43.0a	43.6d	42.2b	41.7
<i>LSD 0.05</i>	0.7	0.4	0.7	0.3	0.6	0.8	--

Alpha linolenic acid content. Alpha linolenic acid (ALA) content was affected by soil N in five of eight site-years (Table 4). ALA generally decreased with increased soil N. Averaged across years, soil N, and

seeding rates, Langdon had the highest ALA content at 52.6 percent followed by Carrington at 51.2 percent and Minot at 49.9 percent.

Table 4. Soil N affect on alpha linolenic acid content of seed oil, ND, 2001-03.

Soil N (lb/acre)	Alpha linolenic acid (%)					<i>average</i>
	Minot 2001	Minot 2002	Carrington 2003	Langdon 2003	Minot 2003	
check	--	51.9a	54.3a	56.6ab	50.8a	53.4
60	48.3a	51.9a	53.3b	56.9a	50.0c	52.1
90	47.3b	51.4b	52.7c	56.2b	50.3b	51.6
120	47.8ab	51.3b	51.8d	55.5c	50.4b	51.4
<i>LSD 0.05</i>	0.6	0.3	0.3	0.5	0.3	--

Seed oil flavor. Cleaned flax seed samples bulked by soil N levels had extracted oil flavor tested by Barleans Organic Oils and Omega Nutrition. Table 5 lists the

general results of the tests. This variable and limited database indicates that factors other than soil N may influence flax oil flavor.

Table 5. Soil N affect on seed oil flavor, Carrington, Langdon, and Minot, 2001-03.

Soil N (lb/acre)	Barleans Organic Oils		Omega Nutrition	
	2001	2002	2002	2003
check	unacceptable	unacceptable	acceptable	acceptable
60		acceptable		marginally acceptable
90		unacceptable		acceptable
120		unacceptable		acceptable

Seeding Rates

Seed yield. Flax seeding rate had minimal effect on seed yield. Yield was affected by seeding rate in two of eight site-years (Table 6). Seeding rates of 20 lbs./acre provided similar seed yield as higher rates. Seed yield averaged across site-years and soil N was 19.0, 19.1, 18.3, and 18.8 bushels/acre with seeding rates of 20, 32, 44, and 56 lbs./acre, respectively. Plant lodging did not differ among seeding rates (data not shown). Trial average and range of flax plant density (three to four weeks after planting) across site-years based on seeding rates is listed in Table 7. With minimal effect on yield with seeding on a lbs/acre basis, there would appear to be no advantage with using a more precise seeding rate based on the number of pure live seeds/acre.

Table 6. Flax yield response to seeding rates (across soil N), Langdon and Minot, 2002.

Seeding rate (lb/acre)	Langdon, 2002	Minot, 2002
	Seed yield (bushels/acre)	
20	16.2a	10.2a
32	17.0b	9.8ab
44	17.7b	9.3ab
56	18.7c	8.9b
<i>LSD 0.05</i>	<i>0.8</i>	<i>1.1</i>

Table 7. Flax plant density with seeding rates, Carrington, Langdon, and Minot, 2001-03.

Seeding rate (lb/acre)	Stand (plants/ft ²)	
	average	range
20*	33	22-45
32*	43	33-59
44*	48	41-84
56**	58	44-66

*seven site-years; **five site-years.

Summary

Trial average flax seed yield from each site-year ranged from 9.5 to 26.5 bushels/acre. Soil N levels of ≤ 90 lbs N/acre were sufficient to support yield. Soil N did not impact plant lodging. Generally seed oil content decreased with > 60 lbs N/acre, and ALA concentration decreased with increasing soil N rates. Also, soil N levels do not appear to impact oil flavor. Seeding rates of 20 lbs./acre (average of 33 plants/ft²) provided similar seed yield and plant lodging as higher rates.

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