Flax Response to Planting Rate

Bryan K. Hanson and **John R. Lukach**

Establishing a flax stand is important in obtaining optimum flax yields. Flax seedling stands may often be poor as a result of deep seeding, soil crusting, a dry or lumpy seedbed, herbicide injury, or other reasons. Determining a planting rate which would produce optimum flax stands and yields and developing criteria to assist producers in replanting decisions are needed in northeastern North Dakota.

Several studies on planting rate effects on flax yield have been conducted. Albrechtsen (1), in 1965 in South Dakota, studied planting rate effects on yield components of flax. Planting rates were 13, 26, 45, and 64 pounds per acre in 12-inch rows. There was no significant seed yield response to planting rate. There was a decrease in bolls per plant as planting rates and plant populations increased. Bolls per plant showed a significant negative correlation (-.827**) with plant population while seed yield was highly correlated (.735**) with bolls per unit of area. Albrechtsen also found plant height to decrease slightly with increased planting rates and maturity to hasten approximately one day with each planting rate increase.

Gubbels (2) studied three flax cultivars at seven planting rates ranging from nine to 93 live seeds per square foot at Morden, Manitoba in 1971-1973. In years with minimal lodging (1971 and 1972) seed yield did not respond to seeding rates above 51 live seeds per square foot. Lodging seriously affected yield in 1973. An inverse relationship between yield and lodging was noted in all cultivars. Higher yields occurred at the lower planting rates which had lower lodging scores.

Gubbels and Kenaschuk (3) studied five flax cultivars at four seeding rates ranging from 19 to 74 live seeds per square foot in 1985-1987. Cultivars varied in their response to seeding rates. Highest seed yields occurred at seeding rates of 37, 56, and 74 live seeds per square foot depending on the cultivar. Gubbels suggested a seeding rate of between 56 and 74 live seeds per square foot should ensure optimum yields in most years.

The objectives of this study were to evaluate planting rate effects on yield and other agronomic traits of flax in northeastern North Dakota, and study the relationship between established plant population and yield and develop criteria for replanting in reduced stand situations.

Hanson is associate agronomist and Lukach is superintendent, Langdon Research Center.

METHODS AND MATERIALS

Trials were located across northeastern North Dakota at one location in 1986, four in 1987, and two in 1988. Trials were grown near Langdon, Cavalier, Tolna, and Cando.

Trials were planted with a plot seeder in a randomized complete block design replicated four times. Depth bands on double disk openers regulated seed depth at 1 to 1½ inches. Seven 6-inch spaced rows 16 feet long were harvested for seed yield. Planting rates for the trials are given in Table 1. Stand counts from each plot were taken after emergence to determine established plant population. Two random 1-yard lengths were counted in each plot. Mercury treated foundation grade 'Flor' flax seed was used in all trials.

All trials in 1987 and the Langdon trial in 1988 were planted the last week of April. Planting dates for the Langdon 1986 and Cavalier 1988 trials were May 14 and 3, respectively. Fertility was adequate for a yield goal of 50 bushels per acre at all locations. Soil series and their classifications are listed in Table 2. Weeds were controlled by the use of herbicides and hand weeding. The plots were threshed with a small plot combine. Samples were dried, cleaned, and weighed for yield and test weight.

RESULTS AND DISCUSSION

Temperature averages and precipitation totals for each environment are given in Table 3. The Langdon 1986 trial was affected by the disease pasmo *(Septoria linicola)* which likely reduced yield and test weight in the trial. Seedbed moisture was limiting at planting time at Langdon in 1987.

Table 1. Flax planting rates for trials conducted in northeastern North Dakota in 1986-1988.

Planting Rate[1]	Target Plant Population	Live Seeds
lbs/a	million plants/a	per ft²
20	1.81	41
30	2.72	62
40	3.63	83
50	4.54	104
60	5.45	125

[1]Planting rate adjusted for percent germination and seed size. Thousand kernel weight = 5 grams.

Table 2. Soil series and their classifications for trial locations in 1986, 1987, and 1988.

Soil Series	Location	Year	Classification
Barnes	Langdon	1986	Fine-loamy, mixed Udic Haploborolls
Svea loam	Langdon	1987	Fine-loamy, mixed Pachic Udic Haploborolls
Svea-Barnes loam	Langdon	1988	
Hamerly loam	Tolna	1987	Fine-loamy, mixed, frigid Aeric Calciaquolls
Tonka silt loam	Cando	1987	Fine, montmorillonite, frigid Argiaquic Argiabolls
Glyndon loam	Cavalier	1988	Coarse-silty, frigid Aeric Calciaquolls
Glyndon loam	Cavalier	1988	

Table 3. Climatological data for May thru August of the 1986, 1987, and 1988 growing seasons at seven environments in northeastern North Dakota.[1]

	1986		1987		1988	
Location	Precip.	Avg. Temp.	Precip.	Avg. Temp.	Precip.	Avg. Temp.
	--- in. ---	------ °F ------	--- in. ---	------ °F ------	--- in. ---	------ °F ------
Langdon	12.29	60.9	14.19	62.3	5.08	66.2
Cavalier	—	—	12.09	65.3	7.48	67.3
Tolna	—	—	18.0	66.5	—	—
Cando	—	—	14.08	[2]	—	—

[1]Climatological Data of North Dakota 1986-1988. National Oceanic Atmospheric Administration. Precipitation and temperatures obtained from the nearest reporting station to each location.

[2]No temperature data available.

No substantial rainfall was received for nearly three weeks resulting in stand reductions. The Cavalier 1988 trial was replanted on May 23 because of very poor stands. Timely rainfall resulted in good yields although rainfall was much below normal. Stands and yields were reduced at Langdon in 1988 because of dry, hot conditions throughout the growing season.

Results from the three-year study were analyzed by treating individual locations and years as separate environments.

Planting rate effects on plant height averaged over environments indicated that as planting rates increased plant height decreased (Table 4). The range between the 20 and 60 pounds per acre planting rate was 1.2 inches. Results from Langdon in 1986 and 1987 indicated that as planting rate increased days to flower decreased. Plants seeded at the 20 pounds per acre planting rate flowered 1.2 days later than those seeded at the 60 pounds per acre rate. These findings are in agreement with previous work (1). Although plant height and days to flower may differ in response to planting rates, there were no major differences which would affect cultural practices by the producer.

There was no significant yield response to planting rate over the seven environments studied. There was, however, a significant planting rate by environment interaction due to lodging. Lodging was present in two environments studied, Langdon 1986 and Cando 1987. Planting rate effect on yield was analyzed further by separating environments into lodging or non-lodging categories. Seed yield increased with increasing planting rates in environments where lodging was absent. The 20 pounds per acre planting rate yielded less than all other planting rates. The 30 pounds per acre planting rate yielded significantly less than the 50 and the 60 pounds per acre rates while the 40 pounds per acre rate yielded significantly less than the 60 pounds per acre rate (Table 5).

Table 4. Planting rate effects on plant height and days to flower of flax in seven northeastern North Dakota environments during the 1986, 1987, and 1988 growing season.

Planting Rate	Plant[1] Height	Days to[2] Flower
lbs/bu	--- in. ---	
20	21.8	47.8
30	21.2	47.4
40	20.9	47.0
50	20.7	46.9
60	20.6	46.6
LSD 5%	0.3	0.5

[1]All environments

[2]Langdon 1986 and 1987 environments

No significant yield response to planting rates was observed when lodging occurred. The two lowest planting rates did, however, have the least lodging and their average yield was 3.5 bushels per acre more than the average of the 40, 50 and 60 pounds per acre planting rates (Table 5). Lodging reduced yield as evidenced by the large negative correlation (-.706**) of yield with lodging. These findings

Table 5. Planting rate effects on flax yield averaged over lodged and non-lodged environments during the 1986, 1987, 1988 growing seasons in northeastern North Dakota.

Planting Rate	Environments		
	Non-Lodged[1]	Lodged[2]	Lodging[2,3]
lbs/a	Yield (bu/a)		0-9
20	23.1	27.2	1.6
30	25.1	27.5	1.9
40	25.6	23.6	4.8
50	26.7	25.0	4.4
60	27.1	23.0	4.3
LSD 5%	1.2	NS	2.4

[1]Langdon 1987 and 1988, Cavalier 1987 and 1988, and Tolna 1987

[2]Langdon 1986 and Cando 1987

[3]Scale — 0 = no lodging, 9 = flat on ground

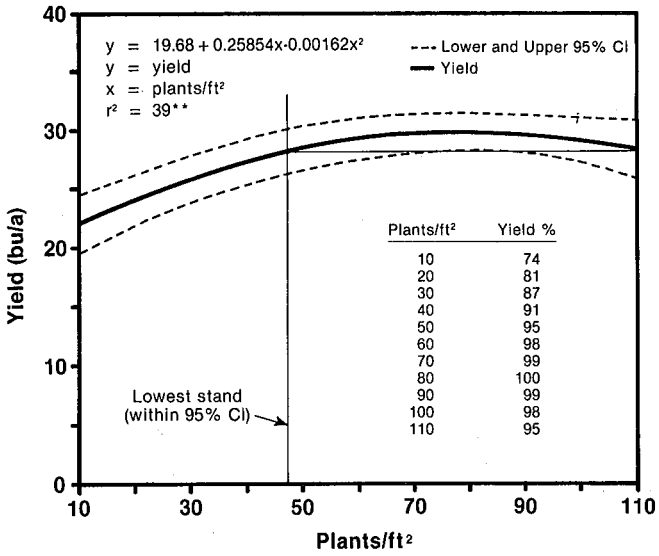

Figure 1. Relationship between plants/ft² and yield of 'Flor' flax at five non-lodged environments in northeastern North Dakota in 1987 and 1988.

are in agreement with earlier work (2,3) which show yield reductions when lodging occurs and increased lodging potential under higher plant densities.

Test weights in non-lodged environments increased slightly at the higher planting rates compared to lower planting rates (Table 6). Significant responses, however, occurred only in Tolna 1987 and Cavalier 1988 trials. Test weights tended to decline as planting rates increased in lodged environments (Langdon 1986 and Cando 1987). Lodging reduced test weight as evidenced by the large negative correlation (-.780**) of lodging with test weight.

The relationship between established plant population and yield were analyzed to develop criteria for replanting in reduced stand situations. The highest yield, across five non-lodged environments, occurred at 80 plants per square foot with no statistical differences between 47 and 110 plants per square foot (Figure 1). This suggests that the minimum established plant population needed to obtain optimum yields would be 47 plants per square foot. No significant yield benefits would be obtained with higher established plant populations. This differs from earlier work done by Gubbels and Gubbels and Kenaschuk (2,3). They suggested planting rates of 51 and 56 to 74 live seeds per square foot, respectively, would produce optimum yields. The planting rates in their studies, however, had from 35 to 80 percent emergence which would result in established plant populations at about 60 percent of what was optimum in this study.

Producers with a field averaging less than 47 plants per square foot would need to make a replanting decision. A replanting decision also involves other factors such as uniformity of the thin stand, weed control, and potential yield reductions due to delayed planting. Figure 1 shows that a flax field planted in the first week of May which established a stand of only 20 plants per square foot could expect yield potential to be reduced approximately 19 percent from the optimum. As an example, Thompson et al (4), showed flax seeded in mid-May, late May, early June, mid-June, and early July yielded 7, 21, 32, 52, and 84 percent less, respectively, than the early May planting. If that producer replanted by mid-May, a 7 percent yield reduction from

Table 6. Planting rate effects on test weight at lodged and non-lodged environments during the 1986, 1987, and 1988 growing seasons in northeastern North Dakota.

Planting Rate	Lodged		Non-Lodged				
	Langdon 1986	Cando 1987	Langdon 1987	Tolna 1987	Cavalier 1987	Langdon 1988	Cavalier 1988
lbs/a	Test Weight (lbs/bu)						
20	53.1	53.4	50.8	51.3	53.0	52.6	53.9
30	53.0	53.1	51.0	52.3	53.4	52.5	54.1
40	53.0	52.3	51.3	52.9	53.8	52.6	54.5
50	52.5	52.8	51.3	53.3	53.8	53.1	54.5
60	52.4	52.1	51.0	53.6	54.0	52.8	53.6
LSD 5%	NS	NS	NS	1.2	NS	NS	0.4

planting date may occur instead of a potential 19 percent reduction due to thin stand. Expected yield increases from replanting would have to be weighed against the extra cost of seed, tillage, and labor.

Percent emergence was also evaluated in this study. Predicting percent emergence of flax in a particular environment is virtually impossible because of the many uncontrolable factors involved. The lowest and highest percent emergences in this study occurred at Langdon and Cavalier in 1988, respectively. Although the average percent emergence difference between the two environments was large (60 percent), the same general trend of decreasing percent emergence with increasing planting rates was observed here and at all other environments. Planting rates (in pounds per acre) and their respective percent emergence averaged over environments were: 20—58, 30—55, 40—55, 50—48, and 60—47. The relationships between target and established plant population, in this study, are given in Figure 2. The decrease in percent emergence as planting rates increased was likely due to increased plant competition within the row. Varying percent emergence and trends of decreasing percent emergence with increasing planting rates have also been observed in other studies (2,3).

The percent of time established flax plant populations, for each planting rate, fell within specified plant population ranges are given in Table 7. The 20 and 30 pounds per acre planting rate had plant populations at or above the minimum for optimum yields, 47 plants per square foot, 0 and 12 percent of the time, respectively. The 40 pounds per acre planting rate had plant populations above 47 plants per square foot 46 percent of the time and just below the minimum 46 percent of the time. The 50 and 60 pounds per acre rates produced the highest number of plant populations above 47 plants per square foot 75 and 96 of the time, respectively.

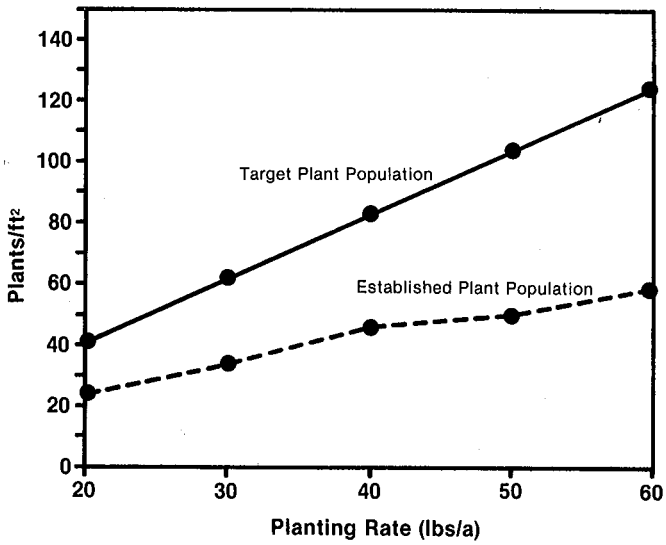

Figure 2. Relationship between target and established flax plant population averaged across seven environments in northeastern North Dakota.

SUMMARY

1. Established plant populations of 47 plants per square foot or greater, in non-lodged environments, produced optimum flax yields. Established plant populations below this level would require a replanting decision by the producer.
2. Established flax plant populations of 10, 20, 30, and 40 plants per square foot, in non-lodged environments, yielded 74, 81, 87, and 91 percent, respectively, of the maximum, which occurred at 80 plants per square foot. This is based on data from uniform stands and very low weed competition.
3. Yield response to planting rate was related to whether or not lodging occurred. In non-lodged environments, yields increased as seeding rate increased from 41 to 125 live seeds per square foot, about 20 to 60 pounds per acre. In the environments where lodging did occur, the lower planting rates of 41 and 62 live seeds per square foot had significantly less lodging than the higher planting rates. The lower lodging levels caused the lower planting rates to have higher yields, though non-significant, than the 40 to 60 pounds per acre planting rate.

Table 7. Percent of time flax plant populations, for each planting rate, fall within specified plant population ranges averaged across six environments in northeastern North Dakota in 1986-1988.

Planting Rate			Established Plants/ft²								
			<17	17-26	27-36	37-46	47-56	57-66	67-76	77-86	>86
lbs/a	—	Live seeds/ft²	%								
20[1]	—	41	0	67	21	12	0	0	0	0	0
30	—	62	0	0	50	38	8	4	0	0	0
40	—	83	0	0	8	46	22	8	8	8	0
50	—	104	0	0	4	21	46	13	4	8	4
60	—	125	0	0	4	0	34	29	12	8	13

[1]24 observations per planting rate

[2]Langdon 1988 data not presented. Stands ranged from only 8 to 29 plants per square foot.

4. Planting rate effects on test weight, plant height, and days to flower were small and would not affect cultural practices by producers.

5. Stand establishment and lodging are unpredictable due to environmental effects. The producer must determine the best planting rate for his environment. The 94 to 104 live seeds per square foot planting rate (approximately 45 to 50 pounds per acre) should produce optimum yields in most years. However, if the producer has experienced lodging under his production techniques, the lowest seeding rate at which a uniform stand can be established should be used.

REFERENCES

1. Albrechtsen, R.S. 1965. Influence of seeding rate on the components of seed yield in flax. Proc. Flax Inst. 35:11-12.

2. Gubbels, G.H. 1978. Interaction of cultivar and seeding rate on various agronomic characteristics of flax. Can. J. Plant Sci. 58:303-309.

3. Gubbels, G.H. and E.O. Kenaschuk. 1989. Effect on seeding rate on plant and seed characteristics of new flax cultivars. Can. J. Plant Sci. 69:791-795.

4. Thompson, C.R., B.K. Hoag, and J.R. Lukach. 1988. Flax variety response to planting date. North Dakota Farm Research. North Dakota Agr. Exp. Sta. 45(5):22-26.