FLAX FERTILITY RECOMMENDATION CHANGES IN NORTH DAKOTA

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Introduction

Flax has traditionally been grown in North Dakota since early settlement by European immigrants. The varieties of flax have been grown for their oil content more than for fiber. Previous recommendations for N and P have been based on yield goal and soil test level. A review of previous research in the region and new research on the role of mychorrhizae on P nutrition has resulted in dropping the P recommendation. Due to the hazard of lodging from over-application of N from unreasonably high yield goal predictions, a single N rate has been adopted, with due consideration for residual soil N levels and the influence of previous crops.

A History of Cultivation and Research

Flax is an ancient crop. It was cultivated mostly for its fiber content in ancient Egypt. Figure 1 shows Egyptian flax harvests from two different wall tombs. One of the main sources of export revenue for the culture was linen. Flax was pulled out by the roots, the roots were dusted off and laid out in bundles and bound using flax braided cord. The fiber was soaked for several days, then "rippled", where the fibers were separated and combed into fibers. Although little is written about the use of the oil, it is likely that flax oil was also used by the ancients.

In North Dakota, flax has been grown since the early settlement by European immigrants. Blooms and bolls at harvest are shown in Figure 2. Flax seed is very small and flows easily in bulk. Care is needed to seal all cracks in combines and trucks at harvest. People have drowned in stored flax. Flax varieties have been mostly grown for its oil, linseed, which is still used in many oil-based paints. Recently, the seed has been used for human consumption, especially with the new omega-3 oil varieties. Flax seed has also been found to have preferable feed qualities for livestock. Cultivation of flax reached a peak in the 1940's and 1950's in the region with the demand for paints during and following WWII.

During the 1950's and 1960's, many research trials were conducted in North Dakota regarding N, P and K requirements. Many of these experiments went unpublished and were instead kept with the researchers' notes and files. The results were sometimes shared with the public at farmer-attended meetings, but certainly the results were shared within the College Soil Science Department for use in developing fertilizer recommendations. Fortunately, some of these files have been saved.

Phosphate

J.C. Zubriski appears to have conducted many of the early flax trials at the North Dakota State Agricultural College, now North Dakota State University. His files are currently being compiled into electronic format. Tables 1 and 2 show summaries of N and P trials. One of the familiar trends is the lack of response to fertilizer P, and a low number of N responsive sites.

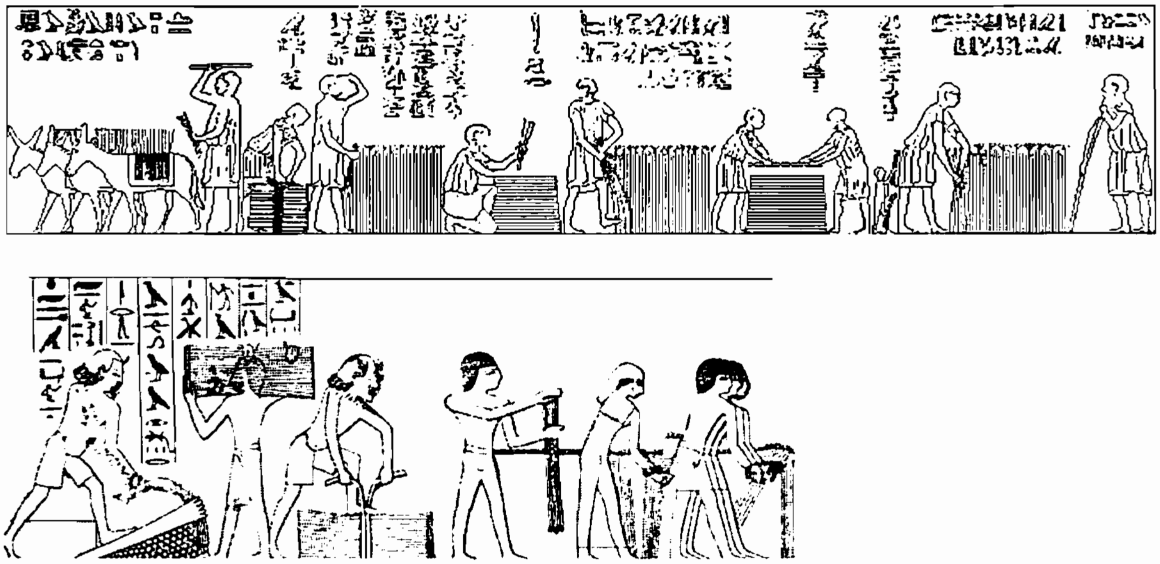

Figure 1. Two depictions of flax harvest and preparation for linen production from Egyptian tomb paintings. Top, from right, the owner of field, two scenes of pulling up flax plants and stacking into piles, tying bundles and transporting off the field. (Lefebrve, G., 1924, *Le Tombeau de Petosiris, Troisieme Partie: Vocabulaire et Planches, L'Institut Francais D'archeologie Orientale,* University of Chicago Library used by permission); Bottom, from right, pulling up flax plants, cleaning off roots, gathering into bundles, tying bundles, transport to rippler to separate fibers. T.G.H. James, 1984, Pharoahs People, University of Chicago Press, Chicago, IL.)

Figure 2. Left, flax in bloom, courtesy of Greg Endres, NDSU Carrington R & E Center. Right, ripe flax bolls.

In an annual report, Zubriski summarizes P fertilization findings by relative soil P levels. (Table 3). The results indicate that flax was unresponsive to P regardless of soil test level. These findings were reinforced by Rasc from Manitoba data. (Table 4). These findings also showed that flax was not responsive to P fertilization at any tested soil P level.

Table 1. Summary of 21 N rate field trials in North Dakota, 1958-1963, J.C. Zubriski, unpublished research.

N rate, lb/acre	Yield, bu/acre
0	14.6
20	16.5
40	17.5
60 or 80	17.5

Table 2. Summary of 15 P rate field trials in North Dakota, 1957-1959, J.C. Zubriski, unpublished research.

N rate, lb/acre	Without P	With P
	Yield, bu/acre	
0	12.5	13.1
20	14.3	13.9
40	14.3	14.6
Mean	**13.7**	**13.9**

Table 3. Summary of P rate field trials in North Dakota, 1957-1959 by soil test P level, J.C. Zubriski, unpublished department research summary.

	Soil test level	
Amendment	Low soil test P	Medium or high soil test P
	Yield, bu/acre	
Check	15.6	14.3
P added	14.4	13.6

Table4. Summary of 15 site years of phosphate application to flax. Rasc, 1980, Canada.

		----------------Yield, bu./acre -----------	
Soil test P levels	Number of sites	No P applied	20 lb./acre P_2O_5
Very Low	3	17	16
Low	3	15	14
Medium	4	19	17
High	5	18	17

However, between these two time periods, Rasc cites two studies by Bailey at two sites in Manitoba, where a yield increase to added P was achieved when there was separation of seed and fertilizer at one of two locations (Rasc, 1980). Although the yield increases in these two studies are substantial, these results were rarely duplicated in older studies, nor in recent times.

Although it is common to achieve yield increases in many crops with P fertilization, it does not appear to be as simple to achieve in flax.

Recent work in Manitoba has shown that flax has a special relationship with mychorrhizae. When P is not added to flax, the mychorrhizae in nearly all but the most P depleted soils appears to be able to mobilize sufficient P for maximum growth and yield. However, when P fertilizer is added, mychorrhizae infection decreases, so that the net result is no benefit to added P (Tables 5, 6, Grant et al., 2004).

Table 5. Effect of P application to flax, P application in the preceding crop, type of preceding crop and tillage system on mycorrhizal incidence (% of root area covered) at two locations (2001). From Grant et al., 2004.

		Site 1						Site 2					
		Canola			Wheat			Canola			Wheat		
P in Flax	Residual P	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
0	0	4.65	5.80	5.23	9.40	8.00	8.70	3.01	6.13	4.57	3.86	8.23	6.05
0	25	4.00	6.85	5.43	9.31	9.68	9.50	3.19	5.47	4.33	3.42	4.01	3.72
0	50	5.65	11.43	8.54	11.38	10.63	11.01	3.25	3.50	3.38	2.33	7.79	5.06
Mean of 0 P		**4.77**	**8.03**	**6.40**	**10.03**	**9.44**	**9.73**	**3.15**	**5.03**	**4.09**	**3.20**	**6.68**	**4.94**
25	0	3.83	4.52	4.18	11.04	6.33	8.69	5.14	4.30	4.72	2.12	5.64	3.88
25	25	5.41	5.85	5.63	7.19	12.68	9.94	3.17	2.70	2.94	1.52	4.33	2.93
25	50	6.40	4.84	5.62	8.10	8.46	8.28	1.90	4.42	3.16	2.18	3.69	2.94
Mean of 25 P		**5.21**	**5.07**	**5.14**	**8.78**	**9.16**	**8.97**	**3.40**	**3.81**	**3.61**	**1.94**	**4.55**	**3.25**
Mean across P		4.99	6.55	5.77	9.40	9.30	9.35	3.28	4.42	3.85	2.57	5.62	4.09

Table 6. Effect of P application to flax, P application in the preceding crop, type of preceding crop tillage system on seed yield (bu/acre) at two locations (2000-2002). P was separated from the seed by about 1 inch. From Grant et al., 2004.

		Site 1						Site 2					
		Canola			Wheat			Canola			Wheat		
P in Flax	Residual P	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
0	0	24.8	25.0	24.9	25.0	28.3	26.7	25.4	22.1	23.7	30.0	27.7	30.1
0	25	23.8	27.0	25.4	26.5	26.6	26.6	24.0	22.1	23.0	28.9	29.4	29.2
0	50	24.4	24.5	24.4	26.8	27.8	27.3	26.3	22.1	24.2	27.3	28.2	27.8
Mean of 0 P		**24.3**	**25.5**	**24.9**	**25.0**	**27.6**	**26.8**	**25.2**	**22.1**	**23.6**	**28.8**	**28.4**	**28.6**
25	0	24.1	25.3	24.7	26.9	27.1	27.0	27.1	21.3	24.2	29.5	28.7	29.1
25	25	25.2	25.8	25.5	29.0	28.6	28.8	23.8	23.8	23.8	30.7	25.6	28.2
25	50	25.6	25.0	25.3	28.8	28.3	28.6	23.8	21.4	22.6	31.1	29.0	30.1
Mean of 25 P		**25.0**	**25.3**	**25.1**	**28.2**	**28.0**	**28.1**	**24.9**	**22.1**	**23.5**	**30.5**	**27.8**	**29.1**
Differences with P were not significant at P 0.05.													

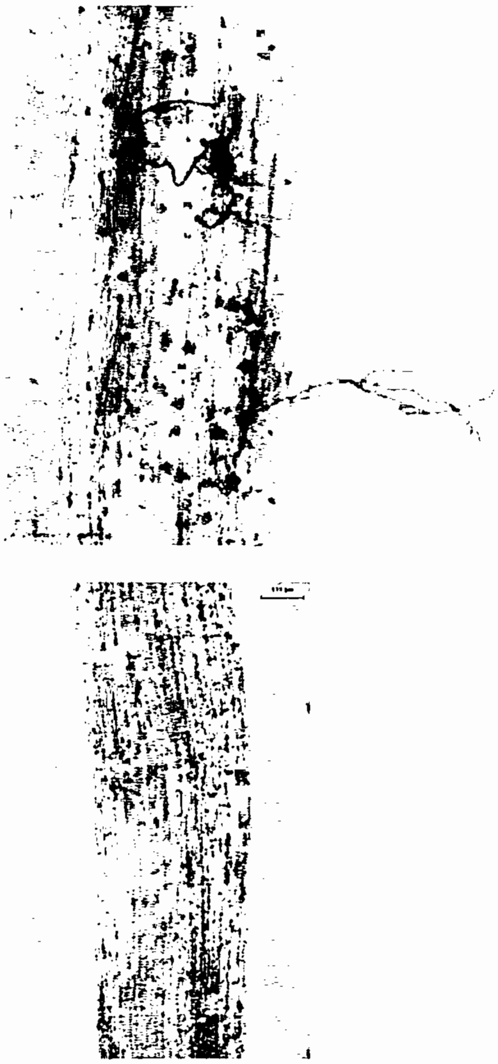

Figure 3. Top, flax root with mychorrhizae infection showing arbuscles and hyphae. Bottom, flax root without mychorrhizae infection. Photos courtesy of Dr. Marcia Monreal, Agriculture and Agri-Food Canada, Brandon, MB, Canada.

Because of the volume of data supporting flax as generally unresponsive to P amendments, North Dakota fertilizer recommendations for flax no longer support P additions. However, the new recommendations support more frequent soil testing for P to prevent depletion of soil test P levels.

Nitrogen

In contrast to the aggressive fertilizer nitrogen strategy used in wheat production, a more conservative approach is used with flax. Although yield increases are possible when nitrogen is applied to flax, other factors are often more important than nitrogen rate. Excessive nitrogen rates may actually reduce yield potential by stimulating more vegetative growth, causing greater susceptibility to disease and lodging. For these reasons, the formula for nitrogen application is similar to previous recommendations (3 X Yield Goal), but there is a need to impose an upper limit of 80 lb. N/acre from residual soil nitrate-N and nitrogen amendments into the equation. Since most growers would be reluctant to choose a yield goal of under 25 bu./acre, a more appropriate recommendation would be to use a flat rate of 80 lb. N/acre as the base rate.

Nitrogen recommendation for flax-

80 lb. N/acre - STN - PCC

STN = soil test nitrate-N sampled to 2 feet in depth

PCC = previous crop N credit (40 lb. N/acre if the previous crop was an annual legume)

In our soils, the use of this conservative formula will not result in under-fertilization of flax with nitrogen. In years where higher yields are possible, mineralization of organic matter N will easily supply the extra needs of the flax crop. In years with more normal or depressed yields due to environment, the N rate will be high enough to nourish the crop, but not high enough to promote disease or lodging.

The use of an 80 lb/acre base N rate is supported by previous work in Canada, South Dakota and North Dakota, as well as recent N calibration work at NDSU (Table 7). In the recent North Dakota studies, seed oil content was generally reduced at rates greater than 60 lb. N/acre, and alpha linolenic acid content of the oil was reduced in five of eight site years with increasing N rates.

Table 7. Summary of N rate studies at Carrington and Langdon, 2001-2003.

N lb/acre	C* 2000	C2001	C 2002	C 2003	L 2001	L 2002	L 2003
	Yield, bu/acre						
Check**	---------	23.7	19.9	20.7	18.0	12.6	15.7
60	26.2	25.8	19.6	23.4	16.8	13.3	17.8
90	26.6	25.5	21.9	25.5	16.6	10.5	20.6
120	23.3	30.8	20.4	27.6	18.3	13.3	22.1
Significance	NS	NS	NS	3.7	NS	NS	1.6

* C = Carrington, L = Langdon

** Check residual N levels, lb./acre- Carrington 2000, 36; Carrington 2001, 44; Carrington 2002, 53; Carrington 2003, 31-53; Langdon 2001, 38; Langdon 2002, 37; Langdon 2003, 37-50 lb/acre.

Summary

Changes have recently been made in North Dakota flax fertilizer recommendations. The lack of yield increases due to P fertilization regardless of soil test level has led to removing P from the list of recommended nutrients for flax. Growers are encouraged to soil test for P more frequently to prevent soil test level depletion.

Due to the hazards of lodging and weed pressure, N fertilization recommendations are limited to 80 lb/acre less soil nitrate measured at the two-foot depth. Zinc and potassium recommendations remain unchanged.

References

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