# LINOLA™ FERTILITY: NITROGEN AND PHOSPHORUS PLACEMENT AND RATE RESPONSE

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## INTRODUCTION

Solin is a type of flax *(Linum usitatissimum* L.) bred to produce a high-quality edible oil. Solin oil is characterized by its high concentration of desirable polyunsaturated linoleic fatty acid (-70%) and low linolenic acid concentration (<3%). The solin cultivar Linola™ 989 has been developed for western Canadian cropping conditions, and provides an alternative to conventional industrial oil flax production (Anonymous, 1996). While agronomic recommendations for nitrogen (N) and phosphorus (P) fertilizer rates and placements exist for conventional flax production in the prairie provinces, the studies which produced these recommendations did not use current cultivars or production techniques, and therefore may be underestimating the crop's yield potential. The nutrient requirements of Linola™ 989 are thought to be similar to high-yielding flax varieties but the specific N and P requirements and the yield potential of this crop in the various soil zones and climatic regions of western Canada is unknown.

Early flax fertility work performed in western Canada showed that placement of N and P fertilizers close to the seed can induce seedling toxicity (Nyborg 196 1; Nyborg and Hennig 1969). While placing fertilizers further away from the seed reduces toxicity to the seedlings, flax is unable to take up P that is located more than a few centimeters away from the plant (Sadler 1980; Sadler and Bailey 1981). Maximizing fertilizer use efficiency and reducing seedling damage with flax will therefore require careful placement of N and P. Several options, including Pre-seed banding, separating N and P bands, or using N and/or P fertilizers with reduced toxicity to the seedling can be used to optimize fertilizer use with flax.

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One product which can reduce seedling damage is the urease inhibitor N-butyl thiophosphoric triamide (NBPT), which reduces $NH_3$ volatilization from decomposing urea (Mulvaney and Bremner 198 1). This product, in conjunction with an effective fertilizer placement program, may be used to increase the yield of flax.

The objectives of this study are:

-To establish response curves and optimum rates of N and P fertilizers in Linola™ production in western Canada.

-To evaluate the effects of various placement methods of N and P fertilizers on seed yield of Linola™.

-To determine the effectiveness of NBPT in increasing solin yield through reduced seedling damage.

## MATERIALS AND METHODS

Two experiments were established at each of 3 locations (Delmas SK, Grassy Lake AB and Melville SK) in May of 1996. Experiment 1 consisted of 4 N rates and 4 P rates laid out as a two-factor randomized complete block design. Nitrogen as urea was applied at 0, 40, 80 and 120 kg $ha^{-1}$ and P as ammonium phosphate (MAP) was applied at 0, 15, 30, and 45 kg $ha^{-1}$. The treatments were replicated 4 times.

Experiment 2 consisted of 6 product/placement treatments and 6 replicates laid out in a randomized complete block design. Nitrogen was applied at 80 kg $ha^{-1}$ as urea banded prior to seeding. One treatment received urea treated with NBPT at 0.15% weight/weight urea fertilizer. Phosphate as MAP was applied at 45 kg $ha^{-1}$ in three ways: in a pre-seed band with or without urea, as a separate band away from the seed at the time of seeding, or in the seed row (Table 1)

Table 1. Treatments used in N and P placement studies

| Number | Treatment |
|---|---|
| 1 | Urea only, pre-seed band |
| 2 | Side band MAP only |
| 3 | Pre-seed band urea + side band MAP |
| 4 | Pre-seed band urea + seed-place MAP |
| 5 | Urea and MAP side band at seeding |
| 6 | Urea+NBPT and MAP side band at seeding |

Treatments were applied to 2x8 m plots in mid May and Linola™ 989 was seeded to achieve a target stand of 350 plants $m^{-2}$. A combine was used to harvest and determine the seed yield of the plots in early October.

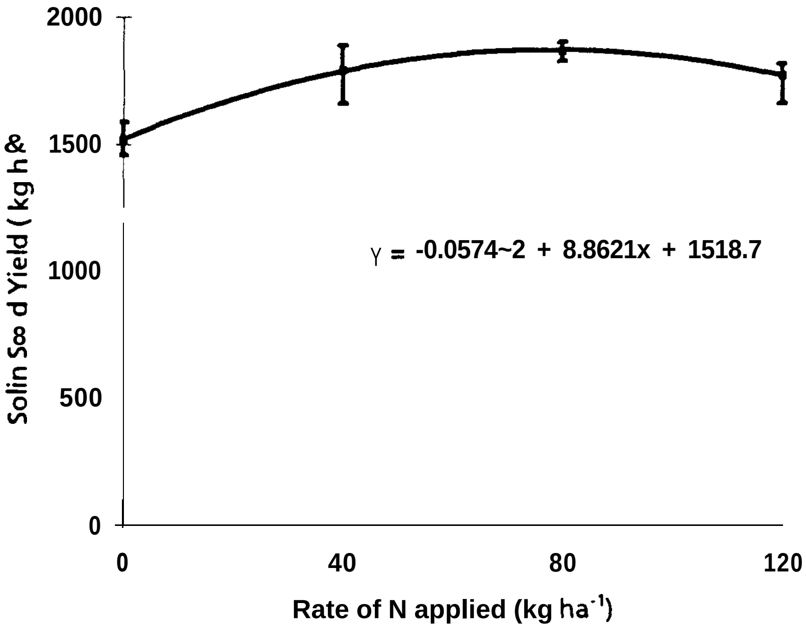
## RESULTS AND DISCUSSION

1. N and P Rate Response

Of the three sites, only one exhibited a significant response to N addition. There was no significant yield response to P fertilization at any site. At Grassy Lake (Brown Chemozem), the highest seed yield of 2501 kg ha-‘, 658 kg ha“ greater than the check, was achieved with the addition of 80 kg $ha^{-1}$ of N. Yield response to N at Delmas (Dark Brown Chemozem) was not significant at $\alpha=0.05$, but did exhibit an increasing trend with N application. The highest yield at this site came with the addition of 40 kg $ha^{-1}$ of N, which increased yield from 1190 to 1324 kg $ha^{-1}$ (p=O.O7). At Melville (Black Chemozem), weed competition and uneven germination led to a high coefficient of variation (28%) and lack of response to N.

Contrast analyses of the combined data from Grassy Lake and Delmas indicated that yield response to N could be described by a quadratic equation and that 80 kg $ha^{-1}$ was the optimum N rate for maximum seed production (Figure 2). The reduction of yield at N rates beyond 80 kg $ha^{-1}$ may be attributed increased vegetative growth, delayed maturity and reduced seed production due to greater amounts of available N later in the growing season. Seedling damage by $NH_3$ volatilization early in the growing season may also play a part in yield reduction at higher N rates.

There was no response to added P, nor was there any significant NxP interaction with the combined data. Previous studies have shown that flax has a small phosphorus requirement, and have demonstrated the crop’s response to fertilizer P sources such as MAP (Ukrainetz *et al.* 1975) . The lack of P requirement in these experiments is likely not due to a lower P requirement in Linola™ 989 than in regular flax, but higher than expected amounts of residual P in the soils at the sites chosen.

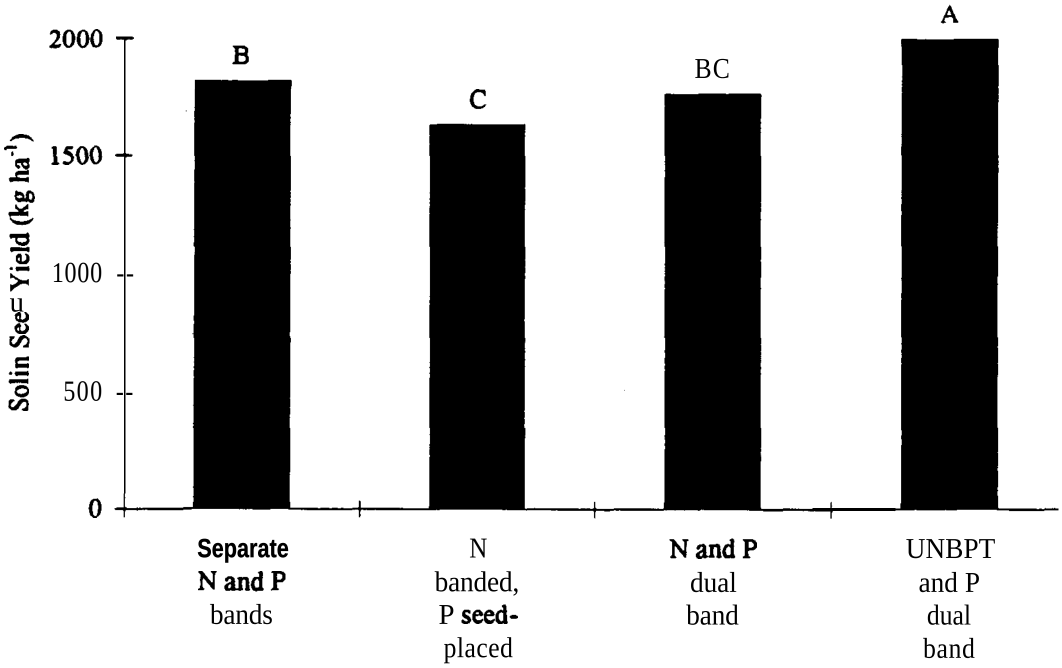



2. Products and Placements

Of the three sites, only Grassy Lake in the brown soil zone had significant response to products or placements. On a Black Chemozem At the Melville site, weed competition and uneven germination resulted in a high coefficient of variation (24%) and no significant response to the treatments. At Delmas, in the dark brown soil zone, dry conditions later in the growing season resulted in poor crop growth and a lack of response to fertilizer placement. The mean yield of solin at Grassy Lake was 1730 kg $ha^{-1}$. At this site urea alone outyielded MAP alone by 280 kg ha“ indicating a stronger response by solin to added N than added P.

In treatments receiving both N and P, placement of the products significantly affected seed yield (Figure 2). The highest seed yield of 1980 kg $ha^{-1}$ was achieved when NBPT-treated urea (UNBPT) and MAP were banded together away from the seed. This was higher (at p=O.O5) than all other treatments including a similar treatment where conventional urea was used instead of UNBPT. Previous studies have indicated that NBPT can be used to reduce the damaging effects of seed placed urea (Pauly et al. 1996; Xiaobin *et al*. 1995). In this case, the sensitivity of solin seedlings to $NH_3$ evolution allowed UNBPT to be effective even when banded away from the seed. Treatments in which urea and MAP were banded separately or together (dual band) performed similarly at this site. When MAP was seed placed (banded N), yields were lower than separate N and P bands but similar to the dual banded treatment.

Figure 3. Solin yield response to products and placements at Grassy Lake.




Seedling sensitivity of flax/solin to ammonia toxicity is well documented (Hocking et al. 1987). The results of the product and placement study at Grassy Lake seem to support the hypothesis that reducing seedling contact with fertilizers reduces seedling damage and results in higher yields. In this case, there was little if any response to added P, and increased damage from either ammonia toxicity or pH reduction close to the seed by MAP outweighed the effects of improved P uptake.

## CONCLUSIONS

Data combined from two sites for one growing season indicate that the yield response of Linola™ 989 to added urea can be described by a quadratic equation, and that maximum seed yield is achieved at a rate of 80 kg $ha^{-1}$ of N. There was no significant response to N at one of three sites in this study, nor was there any response to added P fertilizer at any of the three sites. Lack of response to P was not likely do to a lower requirement of P by Linola™ 989, but by higher than expected soil P levels at the experimental sites.

One of three sites displayed a significant response to fertilizer placement and products. At this site (Grassy Lake) the highest solin yield was achieved with UNBPT banded together with MAP. Seedling damage was likely reduced with the NBPT treatments, resulting in increased yield. Treatments with seed placed P had the lowest yield and there were no differences between individual and dual banded treatments at this site. Because of the lack of P response observed in these experiments, treatments in which solin seedlings were protected from damage were likely to have the highest yields.

## References


Anonymous. 1996. Technical Bulletin: Linola™ 989 -- Solin (Low Linoleic Flax). Proven Seed.

Hocking, P. J., Randall, P. J. and A. Pinkerton. 1987. Mineral nutrition of linseed and fiber flax. Adv. Agron. 41:221-296.

Mulvaney, R.L. and J.M. Bremner. 1981. Control of urea transformations in soil. In Paul, E.A. and Ladd, J.N. (eds), Soil biochemistry Vol 5. Marcel Dekker, New York. pp 153-196.

Nyborg, M. 1961. The effect of fertilizers on emergence of cereal grains, flax and rape. Can. J. Soil Sci. 41:89-98.

Nyborg, M. and A. M. F. Hennig. 1969. Field experiments with different placements of fertilizers for barley, flax and rapeseed. Can. J. Soil Sci. 49:79-88.

Pauly, D. G., Nutting M. and R. E. Dowbenko. 1996. Using a urease inhibitor, N-butyl thiophosphoric triamide (NBPT) for seed-placing nitrogen with wheat, barley and canola. In, Soils and Crops '96. Extension Division, University of Saskatchewan. pp424-430.

Sadler, J. M. 1980. Effects of placement location for phosphorus banded away from the seed on growth and uptake of soil and fertilizer phsophorus by flax. Can. J. Soil Sci. 60:251:262.

Sadler, J. M. and Bailey, L. D. 1981. Effect of placements and rates of band-applied phosphorus on growth and uptake of soil and fertilizer phosphorus by flax. Can. J. Soil Sci. 61:303-310.

Ukrainetz, H., Soper, R. J., and Nyborg, M. 1975. Plant nutrient requirements of oilseed and pulse crops. In J. T. Harapiak (ed.) Oilseed and Pulse Crops in Western Canada--a Symposium. Western Cooperative Fertilizers Limited, Calgary. pp325-374.

Xiaobin, W., Jingfeng, X. Grant, C. A. and L.D. Bailey. 1995. Effects of placement of urea with a urease inhibitor on seedling emergence, N uptake and dry matter yield of wheat. Can. J. Plant Sci. 75:449-452.