NITROGEN INTERFERENCE WITH P-UPTAKE FROM DUAL N-P BANDS

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ABSTRACT

Soft wheat seeded at two different dates following fertilizer application indicated that the fertilizer response pattern to dual deep banded N-P fertilizer can be modified by the length of time the bands are allowed to incubate in the soil prior to seeding. Higher rates of nitrogen in freshly applied dual N-P bands can initially interfere with crop uptake of phosphate. The benefit of including a "starter" phosphate application was greater where the dual N-P bands had been recently applied. The application of starter phosphate resulted in a yield reduction where the dual N-P bands had been allowed to incubate in the soil for three weeks prior to seeding.

OBJECTIVES

Recent studies conducted in Alberta (Harapiak and Flore, 1984) have indicated that higher rates of nitrogen (urea) can at least temporarily, interfere with plant uptake of fertilizer phosphate from dual N-P bands. This research established that if the bands were allowed to incubate in the soil for a period of three weeks, phosphate uptake from the bands was considerably improved. Manitoba based research (Flaten and Racz, 1984) has indicated that a reduction in early P uptake could be attributed to high NH_3 concentrations within the dual N-P band. These initially toxic concentrations would delay root proliferation and therefore P uptake from the core of the dual N-P band. It is also probable that toxic levels of nitrate accumulated in the bands as a direct result of the elevated levels of pH and free ammonia within the bands (Tisdale et al., 1985; Goyal & Huffaker, 1984). Some preliminary research has also suggested that the addition of potash to an N-P band may further aggravate initial P uptake (Harapiak and Penney, 1984).

Based on these research findings, it was decided in the spring of 1982 to establish an experiment using irrigated soft white wheat (Fielder) to demonstrate the practical implications of allowing N-P bands to incubate for a period of three weeks on P-uptake from dual N-P bands and the need for starter phosphate.

MATERIALS AND METHODS

The source of nitrogen was urea (46-0-0) which was applied at a rate of 120 kg/ha of N. The source of phosphate was monocalcium phosphate (0-45-0) which was applied at a rate of 40 kg/ha of P_2O_5. The nitrogen was either broadcast (incorporated) or deep banded using a narrow knife opener. The bands were applied at a spacing of 12" and at a depth of 5". The phosphate was applied either broadcast or deep banded together with the nitrogen or else placed directly in the seedrow. In one treatment, a split application of phosphate was evaluated. Potash was applied as potassium chloride (0-0-62) at the rate of 30 kg/ha of K_2O.

The test site was located near Rockyford in the dark brown soil zone on an alluvial lacusterine parent material. The texture of the surface soil was a heavy loam. Soil samples submitted to the Alberta Soil and Feed Testing Laboratory for routine analysis indicated that nitrate-nitrogen levels were very low (12 lbs/acre in the

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0-24" depth). Available phosphate levels (Miller & Axley) in the surface layer were rated as being low (ie. 15-20 lbs available P per acre). The available K levels for the surface layer ranged between 450-600 lbs per acre which would be considered adequate. The pH of the surface layer was 6.5 and increased to 7.5 (6-12") and 7.9 (12-24") with depth. There was no free lime in the surface layer.

A split-plot design was utilized in that two identical randomized block (six replicates) experiments were established side by side. All of the fertilizer treatments were applied on May 1, 1982. One plot was seeded on the same day, while the other plot was seeded on May 21. The surface soil temperature (0-4") was 46°F and 51°F respectively for the two seeding dates. The wheat was seeded at a rate of 2 bushels/acre.

Harvested grain samples were submitted for N and P analysis using conventional wet chemistry methods. Grain samples were also submitted for moisture, N and P analysis by NIR methods.

RESULTS AND DISCUSSION

Grain Yields

The average grain yield data that was collected in this research trial is summarized in Table 1. The top yields that were achieved in the treatments that received deep banded fertilizer. For nitrogen alone, in terms of grain yield increase due to fertilizer, the banding advantage amounted to 10-20%. This is quite a respectable gain in fertilizer use efficiency considering that these trials received adequate amounts of irrigation water. For the N-P treatments, the banding advantage amounted to 5-50%. On average, the 120 kg/ha of nitrogen that was applied appeared to result in yield increase of approximately 50 bushels/acre. The application of 40 kg/ha of phosphate only resulted in an additional average yield increase of 6 bushels/acre. On average, there was no response to the application of potash fertilizer although there was a trend suggesting a potash response at the early seeding date.

Table 1. Influence of Fertilizer Treatment* and Seeding Date on Yield of Irrigated Soft White Wheat (WCFL, 1982)

Placement Treatment*	Date of Seeding: May		May 21		Average	
	bu/ac	t/ha	bu/ac	t/ha	bu/ac	t/ha
1) Check	20.7	1.39 b	26.9	1.81 d	23.8	1.60 d
2) N B'cast	70.0	4.71a	69.9	4.70 c	70.0	4.70 c
3) N B'cast + P	76.4	5.14a	74.5	5.01 bc	75.4	5.08abc
4) N Band	75.2	5.06a	77.6	5.22 bc	76.4	5.14abc
5) N Band + P	79.4	5.34a	83.1	5.59abc	81.2	5.46ab
6) N-P B'cast	73.3	4.93a	71.2	4.79 c	72.2	4.86 bc
7) N-P Band	76.3	5.13a	92.8	6.24a	84.6	5.68a
8) N-3/4P Band + 1/4P	80.0	5.38a	83.3	5.60abc	81.6	5.49ab
9) N-P-K Band	80.1	5.39a	86.7	5.83ab	83.4	5.61a
10) N-P Band + K	81.3	5.47a	86.2	5.80ab	83.8	5.64a
Average	71.3	4.79	75.2	5.06a	73.2	4.93

Means followed by same letter are not significantly different (Tukey's P=0.05).
Fertilizer applied May 1, and + indicates portion drill-in applied at seeding.
*N = 46-0-0, 120 kg N/ha, P = 0-45-0, 40 kg P_2O_5/ha, K = 0-0-62, 30 kg K_2O/ha.

There was no statistically significant difference between the mean yields for the two different seeding dates. Although there was a significant response to fertilizer for the first seeding date, there were no significant differences among the fertilizer treatments. For the second seeding date, there was no significant difference among the nitrogen banded treatments that received some type of phosphate or phosphate plus potash application.

It is obvious that deep band placement of both nitrogen and phosphate (ie. dual application) was a very effective treatment for the second seeding date. This was quite different for the early seeding date where a drill-in or a split application of phosphate combined with deep banded nitrogen was more effective than a dual deep band application of N & P. This trend would suggest that for the early seeding date, the large amount of nitrogen in the N-P bands could in fact, have initially hindered uptake.

Researchers in Manitoba (Flaten and Racz, 1984) suggested that a reduction in response to P could be associated with low P uptake due to toxic levels of NH_3 within the bands. Based on recent reviews of nitrogen fertilizer behaviour (Tisdale et al., 1985; Goyal & Huffaker, 1984) it is quite probable the accumulation of toxic levels of nitrite within the dual N-P bands shortly after application may have also been a contributing factor to the reduced response to phosphatre applied in dual N-P bands at the early seeding date. The accumulation of nitrite is favoured by elevated pH levels and the presence of free ammonia. It is known that both of these conditions exist within a band following the application of urea. The fact that the later seeded crop responded effectively to phosphate in dual N-P bands would suggest that the bands had become somewhat detoxified with time. This type of response pattern is in keeping with the improved crop uptake of phosphate from N-P bands with time that has been reported based on isotope labelled phosphate trials (Harapiak and Flore, 1984).

The dual N-P band treatment appeared to be very effective for the second seeding date. However, the fact that this particular treatment out yielded similar treatments that contained potash may indicate that the high yields recorded for this treatment may have been an anomaly and could actually be 4-6 bushels per acre high. A potash response on these soils for the early seeding date could possibly be explained by the slightly colder seedbed at the time of planting.

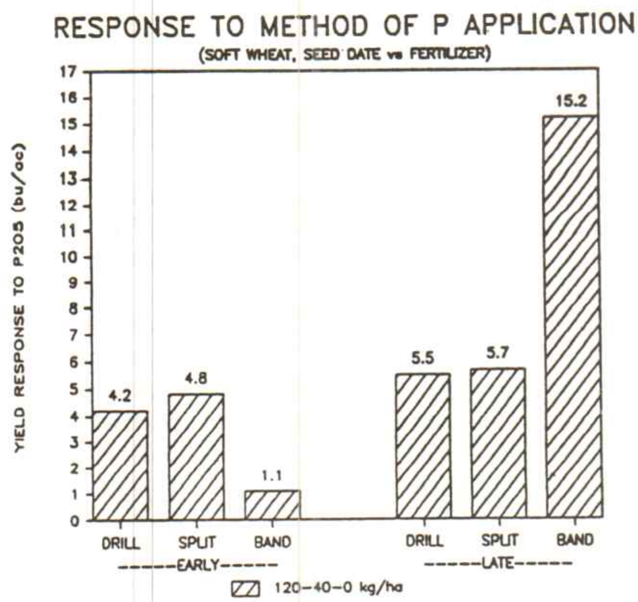

Fig.1. Grain response of irrigated soft white wheat to three methods of phosphate application at two seeding dates (May 1 and May 21) in plots treated with deep banded nitrogen (applied May 1).

The increase in grain yield due to method of phosphate application for the N-P fertilizer treatments that received deep banded nitrogen is summarized in Fig. 1. The results indicate quite clearly that the time of fertilizer banding relative to the time of seeding is an important factor to consider for situations where all of the required phosphate is to be deep banded in combination with a higher rate of nitrogen. Best results will be achieved if the N-P bands are allowed to incubate in the soil for a period of 3 weeks prior to seeding. Alternately, the N-P bands could be fall applied to avoid the problem of nitrogen interference with P uptake.

Nitrogen Uptake

The nitrogen uptake data is summarized in Table 2. The data is presented based on analysis conducted using conventional wet chemistry methods as well as the NIR technique. The statistical analysis was conducted on the latter method simply

Table 2 Influence of Fertilizer Treatment* and Seeding Date on Nitrogen Uptake in Soft White Wheat Grain Based on Conventional and NIR Analysis (WCFL, 1982).

Placement Treatment*	Nitrogen Uptake (kg/ha) May 1 Conventional	May 1 NIR	May 21 Conventional	May 21 NIR	Mean Conventional	Mean NIR
1) Check	24.6	23.4 b	29.9	28.4 d	27.2	25.9 d
2) N B'cast	68.2	69.5a	64.1	67.8 c	66.2	68.6 c
3) N B'cast + P	76.4	71.9a	67.5	72.8 bc	72.0	72.4abc
4) N Band	77.9	72.6a	75.2	79.7abc	76.6	76.2abc
5) N Band + P	81.2	81.7a	78.7	84.8abc	80.0	83.2ab
6) N-P B'cast	71.7	69.3a	66.7	71.6 bc	69.2	70.4 bc
7) N-P Band	77.4	73.9a	91.6	94.2a	84.5	84.0a
8) N-3/4 P Band + 1/4P	82.9	78.1a	81.9	87.3ab	82.4	82.7ab
9) N-P-K Band	82.8	77.4a	81.4	85.7abc	82.1	81.6abc
10) N-P Band + K	81.7	77.3a	83.6	88.2ab	82.6	82.8ab
Average	72.5	69.5 b	72.1	76.0a	72.3	72.8

Means followed by the same letter are not significantly different (Tukey's P = 0.05).
*Fertilizer applied May 1 and + indicates portion of drill in applied.
N = 46-0-0, 120 kg N/ha P = 0-45-0, 40 kg P_2O_5, K = 0-0-62, 30 kg K_2O/ha

because these results were available at an earlier date. The average protein contents based on conventional and NIR analysis were quite comparable (9.27% and 9.29% respectively), although the differences between average values for a given seeding date were somewhat larger.

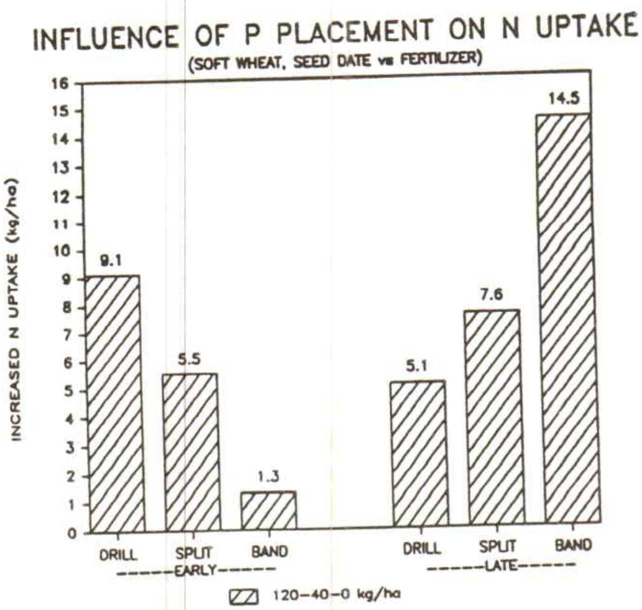

Fig.2. Influence of three methods of phosphate placement and two seeding dates (May 1 and May 21) on enhancing N uptake in grain of irrigated soil and white wheat from plots treated with deep banded nitrogen (applied May 1).

In terms of increased N uptake due to the application of fertilizer, band treatments were more effective than comparable broadcast treatments (44.6 vs 55.2 kg N/ha). The average banding advantage relative to comparable broadcast treatment amounted to 24%. The average N uptake values for the first seeding date were significantly lower than the average N uptakes achieved for the second seeding date.

Although all fertilizer treatments for the first seeding date resulted in a significant increase in N uptake (ie. average N uptake increased by 51.2 kg/ha), there were no significant differences among the fertilizer treatments. The highest N uptake for the first seeding date resulted with deep banded nitrogen and seedrow of applied phosphate.

For the second seeding date, the application of fertilizer increased the average

N uptake by 52.9 kg/ha. The highest N uptake was achieved by the dual banded (N-P) treatment although there were no significant differences among any of the treatments to which all, or at least a portion of the fertilizer was applied by deep banding.

The data summarized in Figure 2 indicates the contrasting influence that method of P placement had an increasing N uptake depending on seeding date for the treatment where nitrogen was applied by deep banding. For the early seeding date, placing all of the phosphate directly in the seedrow was the most effective method of increasing N uptake in the grain portion of the irrigated soft wheat crop. At the later seeding date, placing all of the P directly in the seedrow was less effective than either a split application or placing all of the P in a deep band in combination with the nitrogen.

Phosphate Uptake

The phosphate (P_2O_5) uptake data is summarized in Table 3. The results of both methods of P analysis are tabulated although statistical analysis was only conducted on the P analysis by the NIR method. The average phosphate content (% P) of all the grain samples amounted to 0.32% by the conventional method compared to 0.28% for the NIR method. It would appear that the P analysis by the two methods did not agree as closely as did the N analysis.

In terms of increased P_2O_5 uptake due to the application of fertilizer, band treatments were more effective than comparable broadcast treatments (20.0 vs 23.0 kg P_2O_5/ha). This amounted to a banding advantage of 15%.

Table 3 Influence of Fertilizer Treatment* and Seeding Date on Phosphate Uptake in. Soft White Wheat Grain Based on Conventional and NIR Analysis (WCFL, 1982)

Placement Treatment*	Phosphate (P_2O_5 Uptake (kg/ha)					
	May 1		May 21		Mean	
	Conventional	NIR	Conventional	NIR	Conventional	NIR
1) Check	13.6	9.0 b	15.6	12.4 d	14.6	11.2 d
2) N B'cast	34.3	29.3a	33.5	30.6 bc	33.9	30.0 c
3) N B'cast + P	37.1	31.7a	33.9	34.1abc	35.5	32.9abc
4) N Band	36.2	31.0a	34.8	32.8 bc	35.5	31.9abc
5) N Band + P	37.7	33.8a	37.3	36.2abc	37.5	35.0ab
6) N-P B'cast	36.1	29.7a	33.7	31.6 bc	34.9	30.6 bc
7) N-P Band	37.7	31.5a	40.0	40.2a	38.8	35.8a
8) N-3/4 P Band + 1/4P	39.4	33.9a	37.8	37.0abc	38.6	35.4ab
19) N-P-K Band	39.2	34.3a	38.7	37.3ab	39.0	35.8a
0) N-P Band + K	38.9	33.3a	39.5	37.7ab	39.2	35.5a
Average	35.0	29.8 b	34.5	33.0a	34.8	31.4

Means followed by the same letter are not significantly different (Tukey's P = 0.05).
* Fertilizer applied May 1 and + indicates portion of fertilizer drill in applied.
N = 46-0-0, 120 kg N/ha P = 0-45-0, 40 kg P_2O_5, K = 0-0-62, 30 kg K_2O/ha.

Although all of the fertilizer treatments had a significant effect on increasing uptake of P_2O_5, there were no significant differences among the fertilizer treatments for the first seeding date. For the N-P treatments, the highest P_2O_5 uptake was achieved where phosphate was included in the seedrow. Potash containing treatments also tended to record higher P_2O_5 uptake values. Average phosphate uptake values were significantly lower for the early seeding date.

For the second seeding date, the highest P_2O_5 uptake was achieved by the dual (N-P) deep band application although these values were not significantly different from any other treatment to which phosphate had been applied except for the case in which the phosphate was broadcast applied.

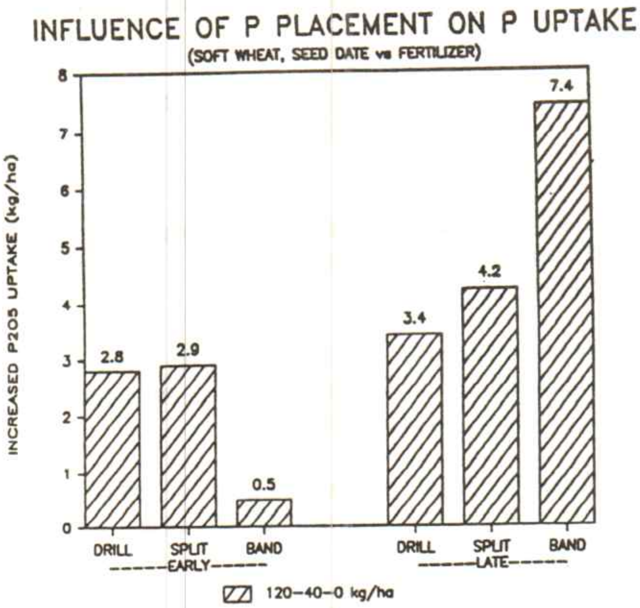

Fig.3. Influence of three methods of phosphate placement and two seeding dates (May 1 and May 21) on enhancing P_2O_5 uptake by grain of irrigated soft white wheat from plots treated with deep banded nitrogen (applied May 1).

The data sumarized in Figure 3 clearly demonstrates that there were large differences in the trends between the options available for phosphate application when nitrogen was applied by deep banding. For the early seeding date, placing all of the phosphate in a deep band in combination with the nitrogen appeared to be least effective in terms of increasing P_2O_5 uptake in the grain portion of the irrigated soft wheat crop. For the second seeding date, placing all of the phosphate directly in the seedrow was not as effective in terms of increasing P_2O_5 uptake in the grain portion of the crop as was a split application of phosphate or placing all of the phosphate in a deep band in combination with the nitrogen (ie. dual banding). It should be re-emphasized that for the second seeding date, the bands were allowed to incubate in the soil for a period of 3 weeks prior to the crop being seeded.

CONCLUSIONS

The information collected from this study demonstrates that when the required N & P are applied in common bands, high concentrations of nitrogen within the bands may initially interfere with fertilizer P uptake for the bands. This interference is only a potential problem as rates of nitrogen approach 100 lbs N/acre in bands applied at a 12" spacing. Since band concentration is also a function of band spacing, increasing the spacing between the bands to 18" could potentially result in poor crop uptake of P from a dual band at a rate approaching 70 lbs N/acre.

While application of compact bands is desirable in the fall of the year to slow the rate of nitrification, more diffuse bands may be desirable for spring application. Application of the bands three weeks prior to seeding can markedly reduce N interference with P uptake from dual bands (Harapiak and Flore, 1984), presumably due to the "mellowing" or detoxification of the high ammonia concentrations within the bands (Flaten and Racz, 1984). Nitrite accumulation within the band may also contribute to reduced P uptake (Tisdale et al., 1985; Goyal and Huffaker, 1984).

The need for application of starter phosphate fertilizer directly in the seedrow to overcome a potential short-term inability of the crop to extract phosphate from dual N-P bands will be most important if the soils are cold, soil moisture levels are favourable at the time of planting and soil phosphate levels are low (Harapiak and Penney, 1984).

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