Have We Oversold The Need For Starter Phosphate?[1]

by J. T. Harapiak and N. A. Flore[2]

The belief that the phosphate fertilizer required for production of cereal crops should always be applied in the seedrow has been well entrenched in Saskatchewan fertilizer recommendations. The basis of this recommendation was the fact that the only other phosphate placement option available at the time the research was conducted (i.e. broadcast and incorporated) was usually only 1/4 to 1/5 as effective in terms of increasing yields.

Increasing rates of fertilizer usage, changes in fertilizer nutrient sources, the trend towards the application of most of the required fertilizer before the busy planting season and the development of new methods of applying fertilizer are forcing a re-examination of what was formerly considered to be an unquestionable recommendation.

Trend to Pre-plant Banding of Nitrogen for Dryland Farming

Farmer concern about getting the maximum value out of the nitrogen that is applied has resulted in a dramatic shift in fertilizer application methods. Whereas in the past, the bulk of the nitrogen was broadcast applied and shallowly incorporated, the trend is now to band the nitrogen into the soil prior to planting to insure the nitrogen is located in the zone where the crop will be actively rooting.

The desire to shift some of the spring workload to fall coupled with the growing realization of the importance of maintaining good seedbed quality, resulted in increasing numbers of farmers banding the bulk of their fertilizer requirements in the fall of the year. As a result of the desires to achieve more timely as well as more rapid planting of the crop there is keen farmer interest in the prospect of applying the required phosphate in combination with the deep banded nitrogen. Is this a viable approach for applying phosphate?

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1. Presented at the Annual Saskatchewan Soils and Crops Workshop, February 13-14, 1984, Saskatoon, Saskatchewan.

2. Manager of Agronomic and Information Services and Field Research Supervisor, Western Co-operative Fertilizers Limited, P. O. Box 2500, Calgary, Alberta T2P 2N1.

Nitrogen Placement Influences Phosphate Benefit

During the 1980-81 period WCFL agronomists established a total of 27 trials of similar design, the average results of which are summarized in Tables 1 and 2. The data in Table 1 summarizes the influence of method of nitrogen placement on the response to phosphate applied directly in the seedrow. Nitrogen was applied at the rate of 50-75 lbs N/acre and phosphate at the rate of 25 lbs P_2O_5/acre. The trials were seeded to wheat or barley.

Based on this information it is readily apparent that on average, drill-in phosphate was more effective when the nitrogen was deep banded rather than broadcast and incorporated.

Table 1: Response of Cereal Crops to Drill-in Phosphate as Influenced by Method of Nitrogen Application

	Yield Increase (bu/acre)		P Response
	N	N+	(bu/acre)
Broadcast	14.1	17.1	3.0
Band	16.1	21.0	4.9

\+ Indicates drill-in P_2O_5 applied
Check yield - 34.6 bushels/acre.
\- based on average of 27 trials.

Table 2: Response of Cereal Crops to Pre-Plant Applications of Nitrogen and Phosphate

	Yield Increase (bu/acre)		P Response
	N	N+P	(bu/acre)
Broadcast	14.1	15.0	0.9
Band	16.1	20.6	4.5

Check yield - 34.6 bushels/acre
\- based on average of 27 trials

The results summarized in Table 2 indicate that the phosphate response when both N+P were broadcast and incorporated amounted to 0.9 bushels/acre compared to 4.5 bushels/acre when both of these nutrients were applied by

deep banding. In other words, the deep band application was 5 times as effective as the broadcast application in terms of response to phosphate. It is interesting to note that this difference in efficiency was equal to that normally suggested as a guideline of the relative difference between drill-in and broadcast placement of phosphate.

In view of the fact that many farmers had already considered broadcasting all of their fertilizer requirements, these results clearly indicate that deep banding rather than drilling-in the required phosphate could be quite acceptable to many farm operators.

Banding Benefit As Influenced By Moisture Conditions

In recent years the major thrust of WCFL's field research program has been directed towards improving our understanding of the circumstances under which deep band or "root zone" placement of fertilizer would be most effective. At an early date it became obvious that climatic conditions were an important factor.

In a general way, the 1980 and 1983 growing seasons were typified by below normal growing season moisture supply while 1981 and 1982 tended to have a more favourable distribution of growig season moisture in the areas in which the trials were located. The average results from 1980 and 1981 are summarized in Table 3.

Table 3: Influence of Year on Response of Dryland Cereal Grain to Method of Fertilizer N-P Placement

Treatment	Yield of Grain (t/ha) 1980*	1981**
Check	1.24	1.50
N Band	2.92	1.99
N Band +	3.06	2.30
N-P Band	3.12	2.25
N-P Band+	3.03	2.40

+ Indicates drill-in P_2O_5 applied.
* All trials seeded to barley.
** Seeded to barley or wheat.
1980 - crop subjected to some degree of moisture stress
1981 - generally favourable moisture conditions

These results clearly demonstrate the superiority of deep band N-P placement method in 1980 and the benefit of including some phosphate in the seedrow in 1981. These results can be contrasted directly to the results obtained from some irrigated wheat trials carried out in 1981 (see Table 4). The results demonstrate that under the generally favourable moisture conditions experienced under irrigation, maximum yields were only achieved when a deep band application of nitrogen and phosphate was combined with some starter fertilizer. This information is consistent with the results that have been observed under favourable moisture conditions for dryland trials, although the benefit of including some starter fertilizer has generally not been as large as observed under irrigation.

Table 4: Response of Irrigated Wheat to Method of Fertilizer N-P Placement (1981)

Treatment	Yield (t/ha)	N-Uptake (kg/ha)	P_2O_5-Uptake (kg/ha)
Check	2.90	52	20
N Band	4.64	87	31
N Band+	4.77	89	30
N-P Band	4.62	84	30
N-P Band+	5.03	95	33

+ Indicates drill-in P_2O_5 applied.

Starting in 1982, the experimental design was modified slightly to include a treatment in which the phosphate application was split (i.e. 2/3 deep banded with the N and 1/3 placed in the seedrow). The results for 1982 and 1983 are summarized in Table 5. The growing season moisture conditions were generally quite favourable in 1982. The 1983 growing season tended to be quite dry. In both years the trials were seeded to wheat or barley.

Table 5: Response of Dryland Cereals Crops to Method of Fertilizer N-P Placement in 1982 and 1983

Treatment	Yield of Grain (t/ha) 1982	1983
Check	1.83	1.39
N Band	2.80	2.21
N Band+	3.03	2.52
N-P Band	2.98	2.65
N-2/3 P Band + 1/3	3.08	2.56

+ Indicates drill-in P_2O_5 applied.

The results summarized in Table 5 clearly demonstrate the influence of growing season moisture conditions on the performance of the various methods of fertilizer applications. In drier years, the application of some phosphate in the seedrow results in lower yields when compared to deep band phosphate placement. On the other hand, this practise can be quite effective in years of more favourable moisture supply.

Band vs Drill-in P_2O_5

During the 1983 growing season, a total of five trials were established where increasing rates of phosphate were applied either deep banded with the nitrogen in the fall of the year or placed directly in the seedrow. The average yield data is summarized in Table 6. The nitrogen was deep banded at the rate of 80 kg N/ha to all treatments in the fall of the year. Three of the trials were seeded to barley, one to wheat and one to canola. The results of these experiments clearly demonstrate the superiority of phosphate deep banded with nitrogen in the fall of the year compared to phosphate placed directly in the seedrow under the conditions experienced in 1983. In all cases, treatments fertilized with deep banded phosphate matured earlier than treatments fertilized with seedrow phosphate. Undoubtedly, the fact that these crops were subjected to some degree of moisture stress throughout the growing season was a factor in explaining the results obtained.

Table 6: Response of Annual Crops to Increasing Rates of Phosphate Applied by Deep Band or Drill-in Placement

Rate of P2O5 (kg/ha)	Response to P2O5 (t/ha)	
	Band	Drill-in
10	0.27	0.15
20	0.50	0.29
30	0.58	0.39
40	0.56	0.38
50	0.73	0.44
Average	0.53	0.33

Absolute check yield - 1.41 t/ha
Nitrogen check yield - 2.13 t/ha
Note: Nitrogen deep banded in the fall of the year for all treatments.

At the time of the writing of this report, N and P analysis had been completed on the grain from only one barley trial and the wheat trial. The calculated N and P uptake for these two trials is summarized in Table 7. The superiority of deep band N-P placement in terms of increased N and P uptake under the growing season conditions experienced in 1983 is readily apparent.

Table 7: Nitrogen and Phosphate Uptake as Influenced by Rate and Method of Phosphate Placement

Rate of P2O5 (kg/ha)	N-Uptake (kg/ha)		P-Uptake (kg/ha)	
	Band	Drill-in	Band	Drill-in
10	70.19	67.19	10.03	9.58
20	73.21	71.21	10.61	10.09
30	75.86	71.66	10.78	10.17
40	76.85	72.75	11.11	10.10
50	79.08	70.57	11.49	10.12
Average	75.04	70.68	10.80	10.01

	Check	N Check
N-uptake (kg/ha)	36.27	64.60
P-uptake (kg/ha)	6.14	8.87

Note: Deep banded N was applied to all treatments in the fall of the year.

Interference of Fertilizer P-Uptake From Bands

Some field observations made by WCFL agronomists raised the suspicion that higher rates of nitrogen deep banded right at the time of planting could interfere with the crop response to phosphate placed in the same band. In 1982, an irrigated soft white wheat study demonstrated that nitrogen applied at the rate of 100 kg N/ha as urea in bands spaced at 12" could interfere with P-uptake. All of the fertilizer was applied on May 1/82 to a split-plot designed experiment. Seeding was conduted on May 1/82 and almost 3 weeks later on May 21/82. The results are summarized in Table 8. At the early seeding date, the response to drill-in phosphate amounted to 0.21 t/ha compared to 0.27 t/ha for the later seeded crop. In the case of the split phosphate treatment, the response to phosphate amounted to 0.24 t/ha and 0.28 t/ha respectively. It would appear that for both of these methods of placement, the responses to phosphate were quite similar for the two dates of seeding. However, in the case of the deep banded N-P treatment, the response to phosphate was only 0.05 t/ha for the early seeded crop and 0.76 t/ha for the later seeding.

Table 8: Influence of Time of Seeding on Response of Irrigated Soft Wheat

Treatment	Yield of Grain (t/ha) Early*	Late**
Check	1.05	1.36
N Band	3.80	3.93
N Band +	4.01	4.20
N-P Band	3.85	4.69
N-2/3P Band + 1/3	4.04	4.21

\+ Indicates drill-in P_2O_5 applied
* Seeded May 1/82
**Seeded May 21/82
Fertilizer banded on May 1/82.

The highest yields were achieved using the deep banded N-P treatment at the later date of seeding. However, for the earlier seeding, deep banded N-P was much less effective. This suggests that the relatively high rate of N placed in the band (100 kg N/ha) interferred with P-uptake. This interference appeared to be overcome if the bands were allowed to "age" or "mellow" for a period of three weeks before the crop was planted.

In 1983 a trial was established to demonstrate by using radioactivity labelled phosphate, that higher rates of banded nitrogen could interfere with phosphate uptake. The results obtained are summarized in Table 9. The highest 32P activity was recorded at the rate of 100 kg N/ha applied 40 days prior to planting (i.e. assigned a relative value of 100), although the same rate of fertilizer applied 20 days prior to planting was about equally effective (i.e. 99%). The results however do clearly demonstrate that higher rates of N applied in the band can seriously interfere with uptake of phosphate. The interference effect is most dramatic if seeding takes place immediately after banding. These results may help to explain why fall banding is often superior to spring banding.

Table 9: Interference of 32P Labelled Phosphate Uptake by High Rates of Banded Nitrogen

Rate of N & P2O5 (kg/ha)	Relative 32P Activity* Application Date			
	May 21/83	June 10/83	June 30/83**	Average
0-45-0	78	77	73	76
50-45-0	88	85	86	86
100-45-0	100	99	74	91
200-45-0	84	36	34	51
300-45-0	70	22	15	36
Average	84	64	56	68

* Based on average of four tissue harvests.
**Barley seeded, June 30/83.
Note: Nitrogen applied as urea (i.e. 46-0-0).

In the case of this study, the bands were spaced at 12". By increasing the spacing to 20" the amount of N placed in each band would effectively by increased. A rate of 60 kg N/ha at 20" spacing would be equal to 100 kg N/ha at 12" spacing. Conversely, if bands were spaced at 8", the rates could be increased to 150 kg N/ha to achieve the type of interference experienced at 100 kg N/ha at 12" spacing.

Some related research has demonstrated that the addition of potash to a N-P band can further aggravate the interference with the ability of crop roots to recover

phosphate from the band (see Table 10). Research conducted for Alberta Agriculture by D. Penney on K deficient soils in 1983 clearly confirms that at relatively high rates of application, barley yields were reduced when all of the fertilizer required was deep banded just prior to seeding compared to placing the required phosphate in the seedrow.

Table 10: Potash Interference With Response of Barley to Phosphate Deep Banded With Nitrogen (A.D.A. - D. Penney)

Treatment	Yield (t/ha)* Grain	Straw
N Band, P Drill-in	1.96	2.32
N+K Band, P Drill-in	3.19	3.32
N+P+K Band	2.76	3.16

*Based on average of 3 trials located in northcentral Alberta.
Fertilizer rates: N - 110 kg/ha
P_2O_5 - 60 kg/ha
K_2O - 60 kg/ha

Summary and Conclusions

1) Research is demonstrating that maximum yields are most likely to be achieved under conditions in which a large percentage of the fertilizer required is deep banded into the soil.

2) Deep band placement of phosphate with nitrogen can be an attractive alternative to placing the phosphate in the seedrow, especially under conditions where the crop is subjected to moisture stress during the growing season.

3) Under favourable growing conditions, yields will often be maximized if 1/4 - 1/3 of the required phosphate is placed directly in the seedrow as a starter fertilizer.

4) Placement of higher rates of ammonium forming nitrogen with phosphate in compact bands near the time of seeding can interfere with P uptake from the band (i.e. maximum of 100 kg N/ha of ammonium forming nitrogen at 12" spacing).

5) Potash fertilizers have a rather high solubility. The addition of potash to a band containing a high rate of N-P fertilizer can further reduce P-uptake from the band.

6) Based on WCFL's field research results, we are recommending that farmers who have the capability to deep band both N and P consider doing so in the fall of the year in the interest of attaining better seedbed quality and more timely planting. In drier areas, the majority of farmers will find that the practise of retaining some phosphate for drill-in application does not consistantly increase yields. In the areas blessed with more favourable moisture, retaining 1/4 - 1/3 of the phosphate for seedrow application may result in additional yield increases, particularly in those years of above average precipitation and below normal temperatures.