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**Title:** Phosphorus fertilizer management decisions for soybean based on time of planting

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**Introduction**

Soybean has been one of the most profitable crops for ND farmers in recent years. This means a well-managed soybean crop could boost yields, minimize input cost, and generate profits to offset some losses producers are experiencing from the production of other crops in rotation with soybeans. Phosphorus management in soybean has been a subject of extensive research, and solid results have been reported with emphasis on rates, methods of application and types of fertilizer to use. Extensive research still needs to be conducted to evaluate fertility management based on soybean planting date, even though a previous research in Carrington had shown that soybean response to P fertilizer did not increase yields, irrespective of planting date and method of application (Kandel et al., 2014). Meanwhile, a recent thesis results from research in Ohio, in soils with medium soil test levels (Hankinson, 2015) showed that soybean yields can be increased significantly by applying P fertilizer on a high testing soil when the crop is planted early. Hankinson’s results showed that high yield potential may explain some of the strong responses to P.

Phosphorus fertility is of concern in the Northern Great Plains because P is mostly unavailable during early growth due to low soil temperatures in early spring. This is particularly important because the trend is for farmers to plant at the earliest date possible, when soils are still warming up. When a young soybean plant experiences P deficiency early in the season, root growth and development can be retarded. This reduces the crop’s access to soil nutrients and its ability to withstand drought stress, especially in western ND. In North Dakota, even though the total P in soils may sometimes be very high, much of it is tied up as insoluble precipitates with calcium rich minerals due to high pH (>7.4) or alkaline soils, leaving very little in solution for plant uptake. The P that is tied up is often available at later growth stages when soil conditions are more suitable for P mineralization. It is possible that the decision to apply P and adjust rates could be influenced by planting date.

An evaluation of the impact of planting dates on soybean response to P fertilization would provide information to farmers to have a better understanding and enable them manage soybean production in ways that can improve P efficiency and minimize cost. This research will therefore benefit the ND farmers by helping them evaluate whether or not P fertilization is needed and at what rate, based on their planting date.

**Objectives**

1. Evaluate soybean P fertility management based on planting date in different environments
2. Provide an economic analysis and implication of observed soybean response to P

**Methods**

This trial was conducted at Minot, Carrington, Oakes, and Wishek, in North Dakota ND, to assess the effect of P fertilization on soybeans planted early, or during normal planting period, or late (Table 1). The trial was designed as a randomized complete block with four replications in a split-plot arrangement with seeding date as main plots and P rates as sub-plots. The four locations chosen (five environments), and the dates of planting are shown on table 1. The P treatments were assessed at the 20 and 40 lbs P/ac rates applied as triple super phosphate, and incorporated. A check treatment of 0 lbs P was also included. At Minot, soybean was no-till and P banded with 11-52-0 (MAP) at 5, 10, and 20 lbs of P2O5 /A.

Table 1. Locations and planting dates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Planting time | **Locations** | | | | |
| -------Carrington ------- | | Minot | Oakes | Wishek |
|  | Dryland | Irrigated | Dryland | Dryland | Dryland |
| Early | 11-May | 11-May | 10-May | 10-May | 9-May |
| Normal | 24-May | 24-May | 19-May | 24-May |  |
| Late | 8-Jun | 8-Jun | 30-May |  |  |

**Results**

At the Carrington site, there were no significant interactions for yields between planting date and P fertility treatments for either dryland (Table 1) of or the irrigated trial (Table 2). The highest yields were obtained with early planting for both dryland and irrigated treatments. Yield differences were however, not significant from normal date planting, but yields from either date were each significantly greater than at late planting. Phosphorus rate impact on yields was not different among treatments under dryland. Meanwhile, under irrigation yields were inexplicably four bushels greater (and significantly so) at 0 lbs. P (56 bushels) compared to average yields at 20 lbs especially that yield differences compared to yields at 40 lbs (54 bushels) were not significant. Average P removal with the seeds at harvest were mainly controlled by the yields. On average, 40 lbs. of P were removed with the seeds for dryland (Table 2), and 35 lbs. for the irrigated study (Table 3).

Prolonged spring and summer droughts at Minot led to low yields, averaging 25 bushels compared to at least 50 bushels normally produced at this location, which explained non-significant yield differences among treatments. Yields were different at Oakes. Yields from early planting were greater (p<0.07) than normal planting date. Yields from P rates were not statistically different between 20 and 40 lbs treatments, but they were significantly greater (increase of 6 bushels; *p<0.05*) than the control (Table 4). Evidently, there was interaction between date of planting and P fertilization. Phosphorus fertilization evidently enhanced seed oil, except that the impact produced significant differences only when planting was later. Seed oil was significantly greater at 20 lbs P than the control at the later planting date. Across all three sites evidently, early planting enhanced oil production in 2017. Meanwhile, the opposite effect was observed for seed protein, which is consistent with the inverse relationship between seed oil and protein in crops. At Wishek, yields were also not different between P rates.

Regarding the economics of P application, it was estimated that if a soybean farmer from Oakes with similar growing conditions had planted early in 2017, they would have realized a net return of $20/ac or $26/ac from applying 20 or 40 lbs P, respectively compared to the check. The return on P fertilizer at the later planting date would have been $3.4/bushel at 20 lbs P, and a loss of $25 at 40 lbs P. Estimates used were $8.5/bu for soybeans, $650/T of TSP ($0.707/lbs P), at an application cost of $6.39/ac. Application of P fertilizer would not have been profitable for the farmer at Carrington, Wishek, or Minot in 2017.

**References**

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