# Effect of Phosphorus on Four Wheat Varieties with Differing Tillering Abilities

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Objective: This study assessed variation in wheat responsiveness to phosphorus to determine if differences are important and consistent to suggest different P recommendations.

**Materials and Methods**

Two trials were planted on May 13, 2016, at two field research sites at the Carrington REC. One site had lower yield potential and low (Olsen soil test) phosphorus (P) at 4 ppm, and the other site had relatively higher yield potential and high soil available P (15 ppm). Both fields were Heimdal silt loam. The fertilizer treatments were 24 lbs $P_2O_5$ applied by broadcast and incorporated as triple super phosphate, versus a control (0 lbs P added). Four wheat varieties, Albany, Bolles, Linkert, and Prosper were planted at both sites at the two P levels. These varieties were selected on the basis that they differ in their yielding and protein content potentials. Albany produces higher yields but lower grain protein than Bolles, meanwhile Linkert and Prosper are two varieties that somewhat fall between Albany and Bolles in those two categories. The experimental design was a randomized complete block with treatments replicated four times. Plants were sampled mid-season to assess the extent of initiation of T1 and T2 tillers of each variety, in response to P. Following harvest, grain yields and protein content were recorded. Normalized Difference Vegetation Index (NDVI), an indication of crop vigor, was recorded with a GreenSeeker pocket sensor at about the 7-leaf stage. Data were subjected to Analysis of Variance, and mean differences were tested by Tukey's honestly significant difference (HSD) test ($P<0.05$) using the Mixed Linear Model analysis in SAS.

**Results**

There were no significant interactions between P treatments and variety, implying that any significant effect of P treatments did not depend on the variety used. There was a significant effect of starter P on yield, KWT, and plant vigor (NDVI) in response to P at the low P site, indicative of increased biomass production with P application. Effect of P was not significant on any response variables measured at the site with high P (Table 1). Response of all variables measured was significant for varieties at the high soil P site, an indication that there were high genetic differences among the four varieties in response to the variables measured at site of high P. The fact that these differences were not consistent with observations at the low P site is probably due to the inherent low productivity of the soil, and problems with weed infestation may not be discounted, accounting in part, for yields that were at least twice less than yields at the more productive site. Average yield increased due to P applied, for each variety planted at each site, ranging from 4.7 to 6.9 bushels at the low soil P, and from 0.2 to 6.6 bushels at high soil test P (Figure 1). An important observation from the yield response results on Figure 1 is that, P application had the highest impact on Albany, when P was deficient in soil, but under sufficient available P, application of P had the greatest impact on Bolles with a 6.6-bushel increase, compared to the second highest at 1.7-bushel increase for Albany. It is probable that an important fraction of the P taken up by Albany was used to enhance tiller vigor, and subsequently enhanced yields, while for Bolles, tiller numbers and vigor were enhanced by P at the high P. Among the four varieties, P enhanced tiller initiation of T1 and T2 tillers on the low P soil; meanwhile at high P, initiation of T1 and T2 tillers was enhanced for Bolles but not the other varieties (Figure 2). However, at low soil P, Linkert had the strongest response to P, increasing T1+T2 and total tillers/plant by over 88%. Albany, which is a high tillering variety, responded the least in tiller initiation and total tiller produced following P application (Figure 3). From this study, application of 24 lbs of P increased yield slightly, by 2.5 bushels (about 5.7%), when soil test P was high, and by 5.6 bushels (33.9%) at the low soil P site. Low tillering Bolles had the biggest yield boost (about 6.6 bushels) from P application even when soil P was high. Availability of P for young spring wheat plants is vital for improving yields, in North Dakota where, soil temperature is low and P availability low.

**Table 1. Effect of starter P on wheat grain yield, quality, and vigor-NDVI, at a low, and a high available soil P site.**

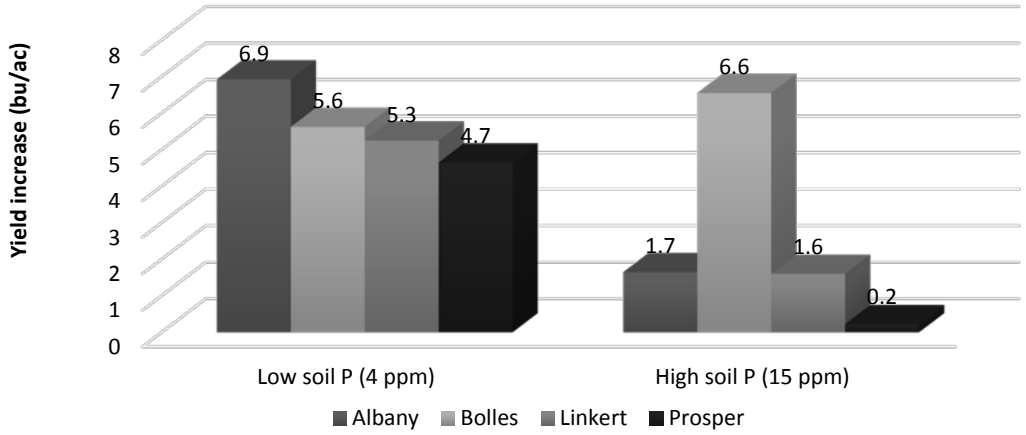
| | Low available P, Olsen test = 4 ppm | | | | | High available P, Olsen test = 15 ppm | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| P Rate (P) | Yield | Protein | TWT | KWT (250) | NDVI | Yield | Protein | TWT | KWT (250) | NDVI |
| lb/ac | bu/ac | % | lb/bu | g | | bu/ac | % | lb/bu | g | |
| 0 | 16.5b | 17.39 | 56.13 | 6.87b | 0.584 | 44.0 | 15.01 | 58.4 | 8.46 | 0.751 |
| 24 | 22.1a | 17.46 | 56.50 | 7.26a | 0.637 | 46.5 | 14.94 | 58.6 | 8.51 | 0.753 |
| *Means* | *19.3* | *17.42* | *56.3* | *7.06* | *0.611* | *45.3* | *14.98* | *58.5* | *8.49* | *0.752* |
| *SED* | *1.445* | *0.284* | *0.235* | *0.140* | *0.009* | *1.682* | *0.161* | *0.104* | *0.101* | *0.006* |
| | | | | | | | | | | |
| Variety (Var) | | | | | | | | | | |
| Albany | 19.9 | 16.82 | 56.68a | 6.35b | 0.589 | 46ab | 13.69ab | 58.68ab | 7.370d | 0.729c |
| Bolles | 17.8 | 17.83 | 55.49b | 7.01a | 0.621 | 42b | 16.29b | 57.94c | 8.355c | 0.766ab |
| Linkert | 20.2 | 17.64 | 56.52a | 7.45a | 0.615 | 43ab | 15.78ab | 58.29bc | 8.841b | 0.745bc |
| Prosper | 19.5 | 17.40 | 56.58a | 7.44a | 0.618 | 50a | 14.15a | 58.96a | 9.364a | 0.769a |
| | | | | | | | | | | |
| *Means* | *19.3* | *17.4* | *56.32* | *7.06* | *0.61* | *45.3* | *14.98* | *58.47* | *8.48* | *0.752* |
| *SED* | *2.043* | *0.402* | *0.333* | *0.198* | *0.125* | *2.379* | *0.228* | *0.198* | *0.143* | *0.008* |
| | | | | | | | | | | |
| *Analysis of Variance (P-*values*)* | | | | | | | | | | |
| *P Rate* | ** | *ns* | *ns* | ** | *** | *ns* | *ns* | *ns* | *ns* | *ns* |
| *Variety* | *ns* | *ns* | ** | *** | *ns* | * | *** | *** | *** | *** |
| *P x Var* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |

TWT = Test Weight, KWT = Kernel Weight, NDVI = Normalized Difference Vegetation Index

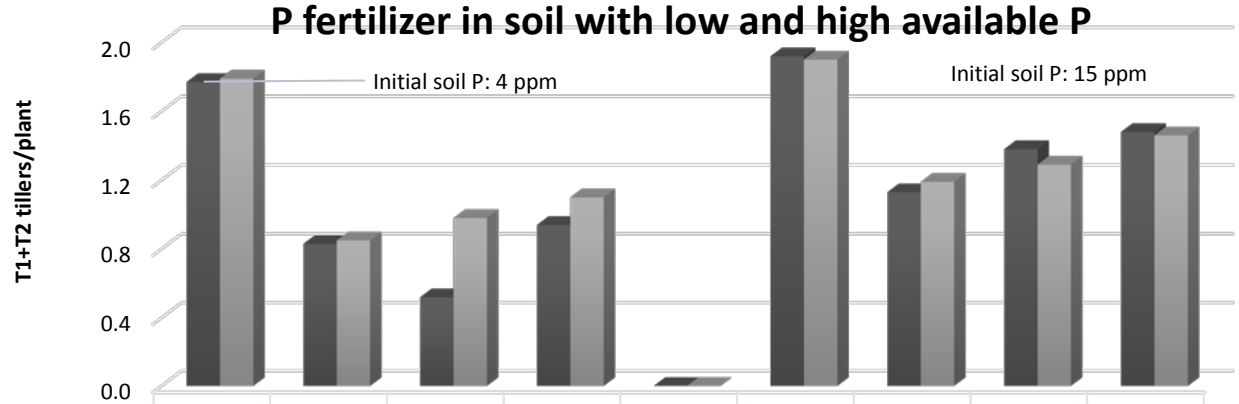
Means separated by different letters are significantly different

*** significant at p<0.0001; ** p<0.001; *p<0.05; ns means not significant

## Fig 1. Impact of applied P to four wheat varieties seeded on soils with low and high P.

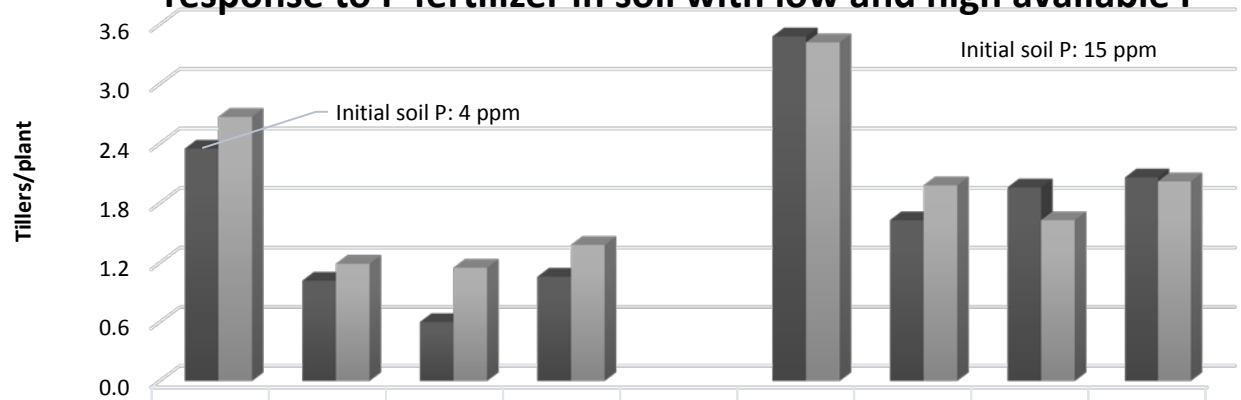



## Fig 2. Tiller initiation of four wheat varieties in response to P fertilizer in soil with low and high available P




| | Albany Low Soil P | Bolles 0 | Linkert 0 | Prosper 0 | | Albany High Soil P | Bolles 0 | Linkert 0 | Prosper 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 lbs P2O5 | 1.77 | 0.83 | 0.52 | 0.94 | 0 | 1.92 | 1.13 | 1.38 | 1.48 |
| 40 lbs P2O5 | 1.79 | 0.85 | 0.98 | 1.1 | 0 | 1.9 | 1.19 | 1.29 | 1.46 |

## Fig 3. Total number of tillers of four wheat varieties in response to P fertilizer in soil with low and high available P




| | Albany Low Soil P | Bolles 0 | Linkert 0 | Prosper 0 | 0 | Albany High Soil P | Bolles 0 | Linkert 0 | Prosper 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 lbs P2O5 | 2.35 | 1.02 | 0.6 | 1.06 | | 3.48 | 1.63 | 1.96 | 2.06 |
| 40 lbs P2O5 | 2.67 | 1.19 | 1.15 | 1.38 | | 3.42 | 1.98 | 1.63 | 2.02 |