Effects of Phosphorus and Potassium Fertilization on Septoria Glume Blotch of Wheat

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ABSTRACT

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A single application of phosphorus (P) and potassium (K) in the fall for wheat-soybean multiple cropping systems is a common practice that can result in excessive fertilization for wheat. The effects of applied and residual P and K and their interactions on Septoria glume blotch, lodging, and yield of wheat were evaluated in a minimum tillage system. In 1978 lodging increased as P levels increased but it was not entirely related to increased vegetative growth. Glume blotch severity was positively correlated with P rates ($R^2=0.76$); 1,000-kernel weight and grain yield were negatively correlated with P rates, glume blotch, and lodging. In 1979, glume blotch ratings decreased at residual soil P levels from seven to 25 kg/ha (additional P and K were not applied in 1979) and then increased as residual soil P levels increased to 45 and 141 kg/ha. Lower plant height at the two lowest P levels probably contributed to greater glume blotch in these treatments. In 1979, 1,000-kernel weight was inversely related to glume blotch on heads. *S. nodorum* infection of seed was not significantly related to P, K, glume blotch, yield, or lodging in either year. *S. nodorum* in seed remaining on the soil surface during the summer declined to nearly zero by September and was not a significant source of inoculum for the next crop. Potassium and P × K interactions did not affect any variable measured except grain yield in 1978 when increasing K rates lessened the detrimental effect of applied P. The results demonstrate that excessive P enhances glume blotch and reduces yield of wheat, but this relationship is not entirely related to lodging and vegetative growth.

Additional key words: minimum tillage, multiple cropping.

In summer-winter double cropping systems in the southern USA, growers are encouraged to plant the summer crop with no-tillage and to apply sufficient fertilizers in the fall for both the winter and summer crop. Application in the fall of phosphorus (P) and potassium (K) sufficient for both wheat (*Triticium aestivum* L. em Thell.) and soybeans (*Glycine max* [L.] Merrill) may result in excessive fertilization for wheat production. High rates of fertilization may reduce yield through nutrient imbalances and increased susceptibility to disease.

Environmental conditions in the southeastern USA often are favorable for glume blotch caused by *Septoria nodorum* Berk. (4,6). The relationship between soil fertility levels and *S. nodorum* infection is not well documented. Shipton et al (9) report that glume blotch was more severe on K-deficient soils than on soils with adequate K. Pirson (7) compared one level of nitrogen (N) fertilizer

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with no N and reported more severe glume blotch when N was added. Bockmann (1) observed that glume blotch increased with increasing levels of applied N and attributed this increase to more vegetative growth. We found no reports of an effect of soil P upon *S. nodorum* infection.

The objectives of this study were: to evaluate the effect of P and K and their interaction on the development of glume blotch and related agronomic and pathological parameters; and to investigate the possibility that wheat seed remaining on the soil surface in no-tillage cropping may be a source of *Septoria nodorum* for the following wheat crop.

MATERIALS AND METHODS

This study was conducted during two seasons in the Piedmont region of Georgia on a Cecil sandy loam (Typic Hapludult) soil. The experimental site had been in continuous fescue pasture for several years prior to 1977. In October, 1977, the pasture was plowed and dolomitic limestone was applied to the soil at 2.9 t/ha. Soil pH throughout the study period ranged from 6.0 to 6.2. In the 0–30 cm soil depth the original P (6 kg/ha) and K (127 kg/ha) levels were low for wheat and/or soybean production (8).

Treatments were a one-time application (October 1977) of five P and five K rates (Table 1) arranged in a 5 × 5 randomized complete block factorial design and replicated four times. All plots were 6.1 × 6.1 m = 37.2 m^2. Two additional standard treatments also were included within the experimental area so that residual and applied P and K could be compared during the second year of the study. These standard treatments were the recommended applications consisting of: 30 kg/ha P and 37 kg/ha K applied in the fall, and 34 kg/ha P and 77 kg/ha K applied in the spring; and 64 kg/ha P and 111 kg/ha K applied in the fall. The original P and K applications were broadcast and incorporated by hand 15–20 cm deep into the soil. Seeds of the susceptible winter wheat cultivar Holley (C.I. 14579) were drilled into a conventionally prepared seedbed in October 1977. After harvest in June, soybeans were no-tillage planted into the wheat stubble and harvested in October. The soil was lightly disked once to help destroy a shallow crust before wheat was again planted in October, 1978.

Ammonium nitrate (28 kg/ha N) was broadcast in October, 1977, but N was not applied in the fall of 1978. In both seasons, 84 kg/ha N was broadcast in late February.

The percentage of glume blotch on heads and lodging within the plots was estimated visually at the dough to mealy ripe stages. Yields were based on 13% grain moisture and were calculated from wheat combined from each plot. Five hundred seeds per treatment were weighed for the determination of 1,000 kernel weight (TKW). Seed infection by *S. nodorum* was determined by plating 400 seeds per treatment on oxgall agar (5). During July, August, and September, wheat seeds were collected from the heads of lodged plants that were not harvested by the combine and were assayed on oxgall agar for *S. nodorum*.

RESULTS

In 1978, glume blotch was the only foliar disease present at a significant level. In 1979, leaf rust was light throughout the field but there was no evidence of an interaction of leaf rust with any P or K treatment. There also was slight damage from scab near maturity. Throughout the study none of the parameters investigated was affected significantly by K. Glume blotch was influenced almost entirely by the effects of P.

TABLE 1. Levels (kg/ha) of phosphorus and potassium applied in 1977 and residual levels in the soil in plots planted (no-tillage) to wheat and soybeans

Fertilizer	Applied[a] October 1977	Residual June 1978[b]	Residual October 1978[c]
Phosphorus	0	11	7
	64	22	11
	128	56	25
	256	108	45
	384	224	141
LSD ($P = 0.05$)	···	34	29
Potassium	0	94	69
	110	139	99
	220	161	123
	440	231	186
	660	255	258
LSD ($P = 0.05$)	···	17	36

[a] Phosphorus and potassium applied prior to wheat planting.
[b] Residual phosphorus and potassium after wheat harvest.
[c] Residual phosphorus and potassium after soybean harvest.

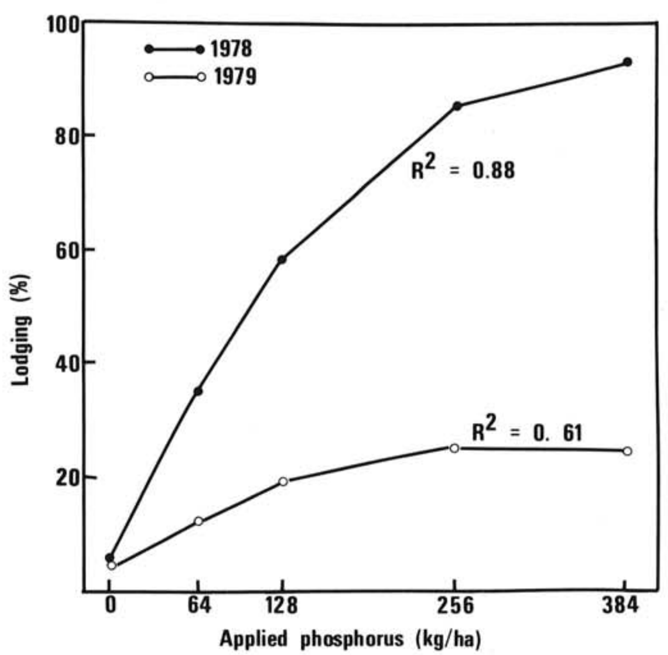

Fig. 1. Percentage lodging of Holley wheat at the dough stage in response to five rates of phosphorus applied to planting in 1977. Each value is averaged over all rates of applied potassium at each rate of phosphorus.

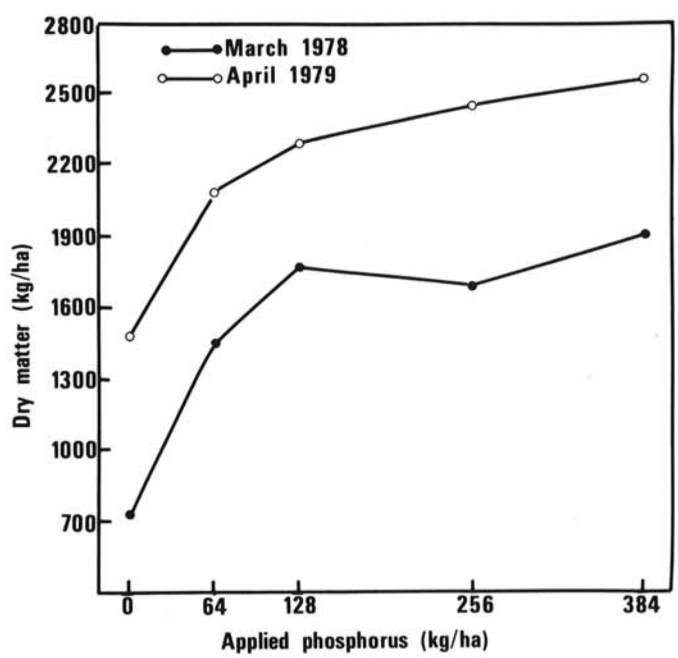

Fig. 2. Vegetative growth of Holley wheat at tillering stage (Feeke's stage 5) in 1978 and jointing stage (Feeke's stage 7) in 1979 in response to five rates of phosphorus applied prior to planting in 1977. Each value is averaged over all rates of applied potassium at each rate of phosphorus.

Lodging and vegetative growth. Lodging at the heading stage was severe in 1978 and increased with higher levels of applied P (Fig. 1). Increased lodging may be the result of corresponding increases in vegetative growth (Fig. 2); however, vegetative growth did not continue to increase as P levels exceeded 128 kg/ha. Lodging in 1979 was not as severe as in 1978, but it did increase as the applied P levels were increased up to 256 kg/ha (Fig. 1). For the annual standard fall application (64 kg/ha P), lodging in 1979 (38%) was slightly higher than in 1978 (34%). Lodging in plots with the standard annual application of P was greater than in plots with the highest residual P level (141 kg/ha soil P and 24% lodging). Vegetative growth in 1979 was greater with high residual soil P than with the standard application. Because lodging continued to increase with higher increments of applied P in 1978 and vegetative growth did not (Fig. 2), the effect of P on lodging is more complex than the simple relationship between vegetative growth and applied P.

Glume blotch ratings. Glume blotch in 1978 increased as rates of applied P increased (Fig. 3). The response of glume blotch to increased P was not as great as was the increase in lodging, however. Glume blotch was less severe in 1979 than in 1978. The response to P was less marked because of the reduced range of soil P levels (Table 1). The rating for the standard fall P and K applications was 35%, similar to the other treatments.

In 1979, plant height at the two lowest rates of P (0 and 64 kg/ha applied P) was reduced 7 and 14 cm, respectively, below the height at the three highest rates of P. Brönnimann (3) demonstrated that glume blotch severity is inversely related to plant height. Reduced height may be a confounding factor for the results of P × glume blotch at the two lowest P rates, thus also affecting yield and TKW.

Grain yield. The main effects of P, increased glume blotch because of increased lodging, were highly significant in 1978 (Table 2); there was also a significant P × K interaction on grain yield. At low K rates (0, 110, and 220 kg/ha) each additional increment of applied P resulted in a yield reduction. At the higher K rates (440 and 660 kg/ha), yield reductions resulting from applied P did not occur until the P levels reached 256 kg/ha. Chemical analyses of plant and grain samples showed that the P × K interaction for grain yield was not a result of severe nutrient imbalances. Yield reductions with increasing P levels were significantly related to lodging and glume blotch.

The highest grain yield in 1979 was less than that obtained in 1978 (Table 2). Except for a low yield at the greatly deficient 0 applied P rate, no significant yield reductions or P × K interactions were observed. At the lower levels, residual P was probably insufficient in 1979. Even though there was a significant residual soil P × glume blotch and a residual soil P × lodging relationship, these two variables could not be directly related to grain yield. The standard application (64 kg/ha P) in 1979 reduced yield by 6% when compared to yield obtained with the P applications of 128,

TABLE 2. The effect of glume blotch on wheat grain yield as influenced by phosphorus (P) and potassium (K) applications in 1978 and by residual soil P in 1979

	Yield, 1978 (kg/ha)						
	K rate (kg/ha)						
P rate (kg/ha)	0	110	220	440	660	Mean	Yield, 1979[a] (kg/ha)
0	2,764	2,522	2,421	2,428	2,455	2,118	1,381
64	3,242	3,437	2,690	3,020	3,087	3,095	2,361
128	2,590	2,192	2,563	3,208	3,054	2,721	2,638
256	2,065	1,977	2,381	2,946	2,428	2,359	2,555
384	1,803	2,025	2,011	1,957	2,085	1,976	2,560
LSD ($P = 0.05$)	525	511	NS[b]	539	404	...	331

[a]No P × K interaction was found in 1979.
[b]Not significant (P = 0.05).

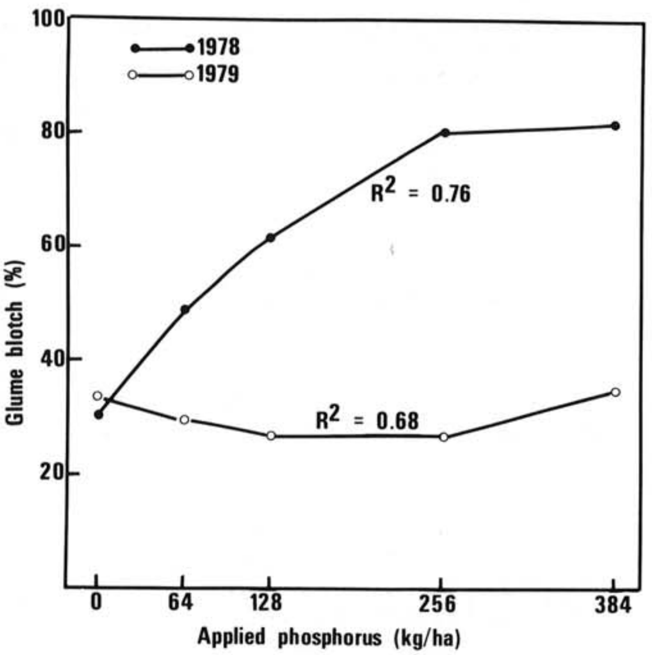

Fig. 3. Percentage glume blotch on heads of Holley wheat at the dough stage in response to five rates of phosphorus applied prior to planting in 1977. Each value is averaged over all rates of applied potassium at each rate of phosphorus.

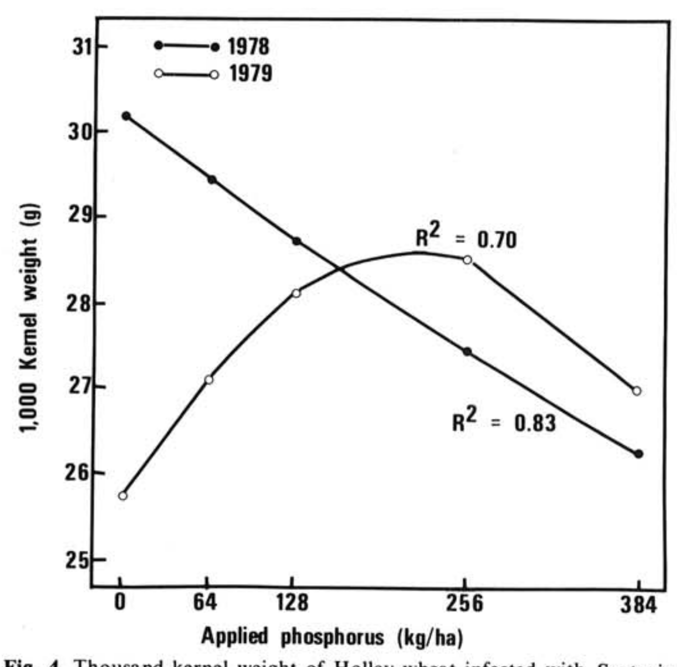

Fig. 4. Thousand-kernel weight of Holley wheat infected with *Septoria nodorum* in response to five rates of phosphorus applied prior to planting in 1977. Each value is averaged over all rates of applied potassium at each rate of phosphorus.

256, and 384 kg/ha (25, 45, and 141 kg/ha residual soil P in 1979). This yield reduction was due to higher lodging (38%) with the standard application than with the other treatments (23% average).

Thousand-kernel weight. The decrease in TKW in 1978 caused by *S. nodorum* paralleled reduction in grain yield as P rates were increased from 64 to 384 kg/ha (Fig. 4). In 1979, TKW response again was the inverse of glume blotch ratings (Figs. 3 and 4). As residual soil P increased TKW decreased more rapidly than the increase in glume blotch ratings. Especially noteworthy was the marked decrease in TKW between the two highest P levels, even though the difference in glume blotch rating was much less. This decrease paralleled the rate of decline in 1978.

Seed infection and survival of *S. nodorum* in unharvested seed. Seed infection among all treatments was high in both years, 55% and 63% in 1978 and 1979, respectively. However, the variation in the severity of glume blotch among fertilizer treatments had no significant effect on seed infection by *S. nodorum*.

Grain lost during harvesting was collected in July, August, and September of each season. *Septoria nodorum* was detected in 36% of the seed collected in August, but was found in only 0.5% of the seed in September, 1978. In July, 1979, 74% of the seeds collected harbored *S. nodorum*, but it was not found in any of 800 seeds collected in August. Most of these seeds were colonized by *Fusarium* sp. In September, no seeds were found in the decayed wheat heads remaining in the field.

DISCUSSION

The primary influence of the increasing rates of P was an increase in lodging at heading stage which created a humid environment conducive to sporulation and infection of the plants by *Septoria nodorum*. Similar P $\times$ lodging responses between years and different P $\times$ glume blotch responses suggest that glume blotch relationships to P cannot be traced entirely to P $\times$ lodging relationships.

Grain yield did not decrease in 1979 although glume blotch ratings were as high as 36%. Yield reductions in 1978 did not occur until glume blotch ratings on the heads at dough stage exceeded 50% (Fig. 3 and Table 2). Thousand-kernel weight, however, was inversely related to each increment in glume blotch rating in 1978 (Figs. 3 and 4). Data for glume blotch severity at earlier stages of grain development were not recorded. Lodging began sooner at the highest P rate than at lesser rates of P. Therefore TKW was reduced more at 384 kg/ha although the rating for glume blotch was the same at 256 and 384 kg/ha at dough stage. These results agree with previous studies which show that TKW is quite sensitive to glume blotch severity (2).

Conidia from the copious numbers of pycnidia in the canopy may have invaded many seeds just prior to maturity. This would account for high levels of seed infection of many florets whose glumes showed little discoloration. Similar results have been obtained in other studies (B. M. Cunfer, *unpublished*). These results agree with earlier reports that infected harvested seed can be an important source of *S. nodorum* (4,5).

Much of the wheat seed remaining among the surface stubble of the no-tillage soybean crop is destroyed by rodents, insects, and microbial decay. Many seed germinate but are killed by a combination of herbicides and shading by the soybeans. Some of the surviving volunteer plants harbor *S. nodorum* and other foliar pathogens (B. M. Cunfer, *unpublished*). However, our data suggest that *S. nodorum* does not survive through the summer in the southeastern USA in seed remaining in the field after harvest.

Reduced labor, energy costs, and soil erosion plus the possibility of greater productivity make multiple cropping with minimum tillage systems a desirable farming practice in the southeastern USA. In many areas fall-planted wheat followed by no-tillage-planted soybeans in early June is a desirable and common cropping system. Added savings in time and labor can be achieved by applying P and K for the wheat and soybean crops prior to planting wheat. Our results show that high levels of K can be applied to wheat with no detrimental effects due to Septoria glume blotch. Fall application of P and K sufficient for the summer crop of soybeans had no deleterious effects on yield (J. T. Touchton, *unpublished*). Because the potential for an epidemic of glume blotch exists each season in the southeastern USA, overfertilization with P should be avoided, especially when soils are high in residual P. Resistant or tolerant cultivars should be planted whenever possible.

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